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INTERSTATE ELECTRONICS CORPORATION
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TITLE

PERFORMANCE SPECIFICATION
MODULATOR/DOPPLER PREDICTOR

SIZE	CODE IDENT NO.	DRAWING NO.	REV.
A	07421	7472306	C

SCALE	REV IN – FILE DATE	SHEET 1 OF 81

IEC-388 (REV 6/90)

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1.0 SCOPE

1.1 GENERAL

This specification defines the performance, design, development, interface, and test requirements for the Modulator/Doppler Predictor (MDP), Interstate Electronics Corporation (IEC) Part Number 7472300, herein also referred to as the unit.

1.2 PURPOSE

The unit will be used in the Second TDRSS Ground Terminal (STGT) User Service Subsystem (USS) to provide modulation of forward link command data, to provide Doppler compensation of the forward link, and to support tracking services. The Tracking and Data Relay Satellite System (TDRSS) is a major segment of NASA's Space Network.

2.0 APPLICABLE DOCUMENTS

The following documents of the exact date of issue, unless otherwise noted, form a part of this specification to the extent specified herein. The order of precedence of this specification relative to the referenced documents shall be as established in 3.8.

2.1 GOVERNMENT DOCUMENTS

2.1.1 Specifications

2.1.1.1 Federal - None.

2.1.1.2 Military

MIL-C-5541	Chemical Conversion Coatings on Aluminum and Aluminum Alloys, Revision D, 28 February 1989
MIL-C-39019	Magnetic Low-Power, Sealed, Trip-Free, Circuit Breakers, General Specifications for Supplement 1, July 1974
MIL-E-16400	Electronic Interior Communication and Navigation Equipment, Naval Ship and Shore: General Specification for Revision H, 13 July 1987
MIL-P-53030	Primer Coating, Epoxy, Water Reducible, Lead Chromate Free December 1983
MIL-P-55110	Printed Wiring Boards, General Specification for Revision D, December 1984
MIL-S-5002	Surface Treatments and Inorganic Coatings for Metal Surfaces of Weapons Systems, Revision D, 30 November 1989

2.1.1.3 National Aeronautics and Space Administration (NASA) - None.

2.1.2 Standards

2.1.2.1 Federal

FED-STD-595	Federal Standard Colors - Paint Revision A, through Notice 9 May 1985
QQ-S-571E	Solder, Lead Alloy, Tin - Lead, and Tin Alloy; Flux, Cord Ribbon and Wire and Solid Form Amendment 4, August 1986

2.1.2.2 Military

MIL-STD-130	Identification Marking of U.S. Military Property Revision G, 11 October 88
MIL-STD-454	General Requirements for Electronic Equipment Revision K, Notice 3, 26 February 1986

MIL-STD-461	Electronic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference, Part 3 Revision C, August 1986
MIL-STD-462	Electromagnetic Interference Characteristics, Measurement of. Through Notice 1, February 1971
MIL-STD-975	NASA Standard Electrical, Electronic, & Electromechanical (EEE) Parts List, Revision G, October 1986
MIL-STD-1130	Connections, Electrical, Solderless, Wrapped Revision B, December 1978
MIL-STD-1472	Human Engineering Design Criteria for Military Systems, Equipment and Facilities, Revision C, May 1984
MIL-STD-1553B	Digital Time Division Command/Response Multiplex Data Bus. Notice 2, 08 September 1986

2.1.2.3 NASA

STDN No. 101.2	Space Networks Users' Guide. GSFC. Revision 6, September 1988.
STDN No. 108	PN Codes for Use with the Tracking and Data Relay Satellite System (TDRSS). December 1976
STDN No. 270.7	GSFC Grounding System Requirements July 1989
STDN No. 927.2	STGT Performance Verification Plan May 1987
STDN No. 927.4	STGT Quality Assurance Plan May 1987

2.1.3 Drawings

2.1.4 Other Publications

IRIG-STD 104-70	IRIG Standard Serial Binary Code Formats August, 1970
MIL-HDBK-217	Reliability Prediction of Electronic Equipment Revision E, October 1986
NHB 6000.1C	Requirements for Packaging, Handling, and Transportation, June 1976
FCC R&R	FCC Rules and Regulations, Part 15 Subpart J for Microprocessor Controlled Devices

2.2 NON-GOVERNMENT DOCUMENTS

2.2.1 Specifications

2.2.1.1 Interstate Electronics Corporation

2.2.1.2 General Electric Corporation/Aerospace

GES-STGT-1323	SSA Equipment HWCI Specification (HWCI No. 5). (aka STGT-HE-04-5) Revision 2, September 1990 Reference correspondence C901-1289 Dated 8 March 1991
GES-STGT-1325	KSA Low Data Rate Equipment HWCI Specification (HWCI No. 7). (aka STGT-HE-04-07) Revision 2, September 1990 Reference correspondence C901-1289 Dated 8 March 1991
GES-STGT-1328	Multiple Access Receiver/Transmitter HWCI Specification (HWCI No. 10). (aka STGT-HE-04-10) Revision 2, September 1990 Reference correspondence C901-1289 Dated 8 March 1991
STGT-HE-06-2	GE Hardware/Hardware Interface Control Document for STGT Appendix G Interface Control Document for Modulator Doppler Predictor - Subsystem Controller/USS ADPE Status and Control 1553B Interface November 1990 through DCN 002

2.2.2 Standards

2.2.3 Drawings

2.2.3.1 Interstate Electronics Corporation

7472302	Drawing Tree Modulator/Doppler Predictor Assembly. 23 October 1989
C901E3860	STGT Unit Test Matrices

2.2.4 Other Publications

NFPA 70	National Electric Code (NEC), 1987
RS-422	EIA Standard, Electrical Characteristics of Balanced Voltage digital Interface Circuits (EIA) Revision 4, December 1978

2.2.4.1 General Electric Corporation

SOW-GE-STGT-8701	Statement of Work (SOW) for USS Equipment SSA Equipment HWCI KSAR Low Data Rate Equipment HWCI MA RCVR/XMTR Equipment HWCI. Latest Revision of November 1989

2.2.4.2 Interstate Electronics Corporation

C901E3331	Configuration Management Plan and Procedures for Second TDRSS Ground Terminal. Contract No. F14000-U16507, SDRL Items CM-01 and CM-02. December 1989
C901-812	Supporting Engineering Analysis Data for Second TDRSS Ground Terminal. Contract No. F14-16507, SDRL No. HE-08. April 1990 This document is known as HE-08.
C903F3379	Training and Training Equipment Plan SDRL LO-02. October 1990

3.0 REQUIREMENTS

3.1 PRIME ITEM DEFINITION

The Modulator/Doppler Predictor (MDP) is an integral part of the STGT User Service Subsystem (USS). The u... provides forward modulation, carrier and code Doppler compensation, and carrier sweep for all S-Band Single Access (SSA), K-Band Single Access (KSA), and Multiple Access (MA) forward user services.

The unit shall provide the following essential functions, as required, and where applicable:

a. Provide data formatting, symbol formatting, and encoding of forward user data.

b. Provide data presence monitoring.

c. Generate PN codes and clocks.

d. PSK modulate the forward carrier with forward data and PN codes. The output carrier will be at a nominal 370 MHz.

e. Provide forward link Doppler compensation, including the capability to:

(1) Simultaneously adjust the forward link carrier frequency and PN code rate in accordance with a commanded profile;

(2) Independently Doppler compensate the carrier and PN code rate for S-Shuttle support.

(3) Receive Doppler updates from the data bus via the Primary Interface;

(4) Enable and disable Doppler compensation as commanded. This includes the capability to ramp the carrier frequency linearly to a specified target frequency.

f. To assist user satellite (USAT) acquisition or reacquisition, provide the capability to sweep the forward carrier and PN code, or, to force a reacquisition, provide a step in carrier and code frequency to break lock on the forward link.

g. Provide tuning of the carrier frequency to accommodate service assignment (SSA, KSA, and MA) and user frequency assignment.

h. Provide support for tracking services including:

(1) Time Transfer Measurement;

(2) Range Zero Set.

i. Generate status data, including self-test and fault isolation information.

j. Generate test signals, including an unmodulated IF carrier output.

k. Communicate with the MIL-STD-1553B data bus via the Primary Interface.

l. To support maintenance and operation, provide front panel and maintenance panel controls, indicators, and test points, as specified.

3.1.1 Prime Item Diagrams

Figure 1 provides a functional diagram of a USS forward service chain. Figure 2 relates the MDP unit functions to the functions required for a USS forward service chain. Figure 3 shows a block diagram of the unit with major components illustrated. Figure 4 provides the functional flow among major components. The unit front panel is shown in figure 5. The maintenance panel is illustrated in figure 6. The unit back panel is shown in figure 7.

3.1.2 Interface Definition

Consistent with the criteria for configuration item identification in STDN No. 927.1, section 2.3.2, the MDP will be treated as a single configuration item and may be used interchangeably in the SSA Equipment, KSA Low Data Rate Equipment, or MA Receiver/Transmitter hardware configuration items. The unit has three interfaces; (1) a back panel interface, (2) a front panel interface, and (3) a maintenance panel interface.

a. Connectors and signals - Tables I, II, and III show the connector termination and signal identification for the unit's interfaces. Table IV provides further identification of connector types.

b. Functional and physical interfaces - The primary control and interface with the unit is via the back panel interface. Secondary, but limited, control and interface are provided on the front panel and maintenance panel interfaces. The back panel interface will be called the Primary Interface. Note that the unit's interfaces all begin and end at the unit. That is, no cables or power cords are provided with the unit.

c. Primary Interface - On one side of the Primary Interface is the MDP provided by Interstate Electronics Corporation. On the other side are all other configuration items (such as Subsystem Controller, Baseband Switch, etc.) which are controlled by General Electric.

3.1.2.1 Primary AC Power - Power will be provided to the unit from the Primary Interface. The unit shall be designed to utilize Primary AC Power which possesses the signal characteristics and unit interface requirements described in table V.

3.1.2.2 MIL-STD-1553B Data Bus - The unit shall communicate with the Primary Interface via a MIL-STD-1553B Digital Time Division Command/Response Multiplex Data Bus, herein also called the data bus. The unit shall be configured as a remote terminal on the data bus. The associated Primary Interface will provide the bus controller. The unit shall meet the interface requirements of STGT-HE-06-2, Appendix G. A list of messages and a description of characteristics are given below:

a. Data bus commands - Messages from the bus controller to the MDP remote terminal are called commands. They are:

(1) MDP_SET_STATE_COMMAND
(2) MDP_SPECIFIC_CONFIGURATION_COMMAND
(3) MDP_COMMON_CONFIGURATION_COMMAND
(4) MDP_DOWNLOAD_COMMAND
(5) MDP_EPHEMERIS_DATA_COMMAND
(6) MDP_FWD_FREQUENCY_SWEEP_COMMAND
(7) MDP_FWD_BREAK_LOCK_COMMAND
(8) MDP_FWD_DOPPLER_COMP_CONTROL_COMMAND
(9) MDP_START_SERVICE_COMMAND

b. Data bus reports - Messages from the MDP remote terminal to the bus controller are called status reports. They are:

(1) MDP_SPECIFIC_CONFIGURATION_REPORT
(2) MDP_COMMON_CONFIGURATION_REPORT
(3) MDP_PERFORMANCE_REPORT
(4) MDP_EXTENDED_BIT_REPORT
(5) MDP_TIME_TRANSFER_REPORT

c. Remote terminal address - See tables I and VI.

d. Redundant bus support - The unit shall provide support for a single data bus with redundant bus inputs.

e. Data bus rules - Additional rules and details of data bus operation are contained in STGT-HE-06-2.

f. Signal characteristics and unit interface - See table VI.

3.1.2.2.1 Reconfiguration - The MDP shall respond to configuration commands received while in the IN SERVICE operating state in one of two manners (Recovery or Restart) depending on the parameters changed.

3.1.2.2.1.1 Recovery Reconfiguration

a. Applicable Parameters - The MDP shall perform a Recovery Reconfiguration when it receives a configuration command to effect one or more of the following changes, but no others:

(1) Inhibit or enable PN modulation
(2) Change in Shuttle mode
(3) Change in data rate
(4) Change in operational light state

b. Implementation of Recovery Reconfigurations

(1) For Recovery Reconfigurations, the MDP shall implement the commanded configuration changes without interruption of the IF carrier.

(2) Changes in data rate or Shuttle mode shall be implemented by the MDP so as to have no effect on the synchronization of the PN code.

c. Timing - The MDP shall be capable of completely implementing any commanded Recovery Reconfiguration within one second after receipt of the command.

3.1.2.2.1.2 Restart Reconfiguration

a. Applicable Parameters - The MDP shall perform a Restart Configuration when it receives an MDP_COMMON_CONFIGURATION_COMMAND or an MDP_SPECIFIC_CONFIGURATION_COMMAND to effect any changes other than those listed as Recovery reconfigurations in 3.1.2.2.1.1.

b. Implementation of Restart Configurations - For Restart Configurations, the MDP shall stop all ongoing modulation operations, implement the commanded configuration changes, and remain in the CONFIGURED operating state awaiting a new MDP_START_SERVICE_COMMAND.

c. Timing - The MDP shall be capable of completely implementing any commanded Restart Reconfiguration within two seconds after receipt of the commands.

3.1.2.3 Common Time and Frequency System (CTFS) - The unit shall receive and utilize for timing reference the following CTFS inputs from the Primary Interface:

a. CTFS 10 MHz
b. CTFS 1 Pulse Per Second (1 PPS)
c. CTFS Time of Year (TOY)

3.1.2.3.1 CTFS 10 MHz - The signal characteristics and unit interface requirements are given in table VII.

3.1.2.3.2 CTFS 1 PPS - The signal characteristics and unit interface requirements are given in table VIII.

3.1.2.3.3 CTFS TOY - The signal characteristics and unit interface requirements are given in table IX.

3.1.2.3.4 Relationship between 10 MHz and 1 PPS - The 10 MHz and the 1 PPS CTFS signals are coherent in frequency. That is, there are exactly 10 million cycles of the 10 MHz signal between successive leading edges of the 1 PPS pulses. However, the signals are unsynchronized in the sense that the leading edge of the 1 PPS pulse is not necessarily aligned with a zero crossing of the 10 MHz sinusoid.

3.1.2.3.5 Leap Year and Second - The unit makes no special provisions for leap year or leap second. The unit accepts ephemeris data and processes it sequentially from the receipt of the data.

a. Leap year - In the case of leap year, the unit sequences on a twenty-four hour cycle and no special operations procedures are required.

b. Leap second - In the case of leap second, implementation of a leap second during a service will result in a time bias in the ephemeris file and in synchronous commands. This may require special operations procedures.

c. Implications - Leap year has no effect on unit tracking or data services. Leap second has no effect on unit data processing (except for synchronous reconfiguration commands). Tracking services may contain anomalies if the one second bias is not managed operationally.

3.1.2.4 Modulated 370 MHz IF - The unit shall provide a modulated 370 MHz signal with the characteristics and unit interface requirements given in table X.

3.1.2.5 Unmodulated 370 MHz IF - The unit shall provide an unmodulated 370 MHz signal with the characteristics and unit interface requirements given in table XI. This signal shall be provided as a front panel signal.

3.1.2.6 USS Forward Data and Clock - The unit shall receive USS forward data and clock from the Primary Interface. These signals will have the characteristics and unit interface requirements given in table XII. Clock and data relationships are illustrated in figure 8.

3.1.2.7 Controls, Indicators, and Test Points - Controls, indicators, and test points are provided on the front panel of the unit and on a maintenance panel to support maintenance and operation of the unit, . For switches with mechanical positions, the position will provide an indication of status. AC power shall be indicated by switch position and by a status lamp.

3.1.2.7.1 Controls - Controls are provided on the front panel and on the maintenance panel.

a. Front panel - The unit shall have the following front panel controls:

(1) AC Power On/Off
(2) Local/Remote Switch
(3) Initiate Built-in-Test (BIT)

b. Maintenance panel - A reset switch shall be provided on the maintenance panel.

c. Local/Remote - A Local/Remote switch shall be provided on the MDP front panel. The switch shall have the following controls:

(1) The Local/Remote selector switch on the front panel shall enable an operator to gain local control of the MDP, or to relinquish control to the 1553 Bus. Selection or relinquishment of local control shall be possible only from the front panel.

(2) When in Remote mode, the MDP shall respond only to commands provided over the 1553 Bus, and not to front panel controls, except those for status display and for Local/Remote selection.

(3) When in Local mode, the MDP shall respond only to front panel controls, and not to commands provided over the 1553 Bus, except for status requests.

(4) All BIT/BITE functions shall be commandable from the front panel when the MDP is in local mode.

(5) All required front-panel status shall be available, regardless of whether local or remote mode is selected.

(6) All status shall be provided over the 1553 Bus, upon command from the SSA Control HWCI, regardless of whether local or remote mode is selected.

(7) Changing from Local mode to Remote mode, or Remote to Local, shall not alter the configuration state of the equipment.

3.1.2.7.2 Indicators - The following indicators are provided on the unit's front panel:

a. Power supply status - Indicator lamps provide a positive indication for each of the following power supplies:

(1) AC Power
(2) + 5 volts DC
(3) + 12 volts DC
(4) + 15 volts DC
(5) + 5 volts DC (RF supply)
(6) - 5.2 volts DC
(7) - 12 volts DC
(8) - 15 volts DC

b. Unit status - The following indicator lamps provide unit status:

(1) Normal
(2) Fault
(3) Test
(4) On-line
(5) Standby
(6) Maintenance

c. Switch positions - In addition to a status lamp, AC power is indicated by on/off switch position. Switch position is also used to indicate whether the unit is under local or remote control.

3.1.2.7.3 Test Points - Test points are provided on both the front panel and on the maintenance panel.

a. Front panel - The Unmodulated 370 MHz IF signal is a required unit output, provided on the front panel. It may be used as a test point unless operational requirements restrict such use.

b. Maintenance panel - The following test points are provided on the maintenance panel:

(1) Power supplies:

+ 5 volts DC
+ 12 volts DC
+ 15 volts DC
- 15 volts DC
+ 5 volts DC (RF supply)
- 5.2 volts DC
- 12 volts DC
Ground

(2) Test signals:

Forward user Data
Forward user Clock
Range PN Code
Range PN Epoch
Command PN Code
Command PN Epoch
1 Pulse Per Second Internal
PN Code Clock
CTFS 1 PPS External
CTFS 10 MHz
370 MHz Modulated
370 MHz Unmodulated

3.1.3 Major Component List
The components of the MDP are listed in IEC Drawing Number 7472302. The major components are:

a. 7473000 Timing Generator PWA
b. 7473600 Modem Control Processor PWA
c. 7473800 Data Conditioning and Encoding PWA
d. 7474600 Synthesizer PWA
e. 7474800 Forward Modulator PWA

PWA stands for printed wiring assembly.

3.1.4 Government Furnished Property List
The unit neither requires nor contains any government furnished property.

3.1.5 Government Loaned Property List
The unit neither requires nor contains any government loaned property.

3.2 CHARACTERISTICS

3.2.1 Performance
This section provides the performance characteristics of the MDP. The unit shall perform the functions stated over the limits specified.

3.2.1.1 Data Formatting and Encoding - The unit shall provide data formatting, symbol formatting, and encoding of forward user data, as specified. The unit will accept data rates ranging from 100 bps to 25 Mbps, in increments of 1 bps, within the limits specified for SSA, SSH, KSA, KSH, and MA forward services.

a. SSA Forward (SSAF) - SSAF data rates may range from 100 bps to 300 kbps. The input data format may be NRZ-L, -M, or -S. The unit shall accommodate any change to the actual input data rate in this range without being notified by the data bus. No data formatting or encoding is required for SSAF.

b. SSH Forward (SSHF) - SSHF data rates are restricted to 32 kbps for Mode 1 and 72 kbps for Mode 2. The input data format shall always be NRZ-L. The unit must be commanded by the data bus to configure for Mode 1 or Mode 2. The input NRZ-L data shall be convolutionally encoded by the MDP. The encoded symbols shall then be format converted to Biphase-L by the unit.

(1) Convolutional encoding - The encoder for S-Shuttle input data shall possess the following characteristics:

(a)	Code rate	1/3
(b)	Constraint length	k = 7
(c)	Generator functions	G1 = 1111001 G2 = 1011011 G3 = 1100101

(2) Synchronization - The S-Shuttle encoder shall synchronize within 1000 symbols of being configured, or reconfigured, by the data bus provided the correct Mode 1 or Mode 2 input is also configured. Input data rate will be to the accuracy of the CTFS.

(3) Status reporting - Encoder synchronization, i.e., encoder lock status, will be provided in the MDP_PERFORMANCE_REPORT. Lock status will be sampled once per second.

c. KSA Forward (KSAF) - KSAF data rates may range from 1 kbps to 25 Mbps. The input data format may be NRZ-L, -M, or -S. For data rates less than or equal to 300 kbps, the unit shall accommodate any change to the actual data rate without being notified by the data bus. No data formatting or encoding is required for KSAF.

d. KSH Forward (KSHF) - KSHF data rates are restricted to 216 kbps for Mode 1 and 72 kbps for Mode 2. The input data format shall be NRZ-L, only. The data bus will inform the unit as to Mode 1 or Mode 2 configuration. The unit shall convert the NRZ-L input data to Biphase-L format. No encoding is required.

e. MA Forward (MAF) - MAF data rates may range from 100 bps to 10 kbps. The input data format may be NRZ-L, -M, or -S. The unit shall accommodate any change to the actual input data rate in this range without being notified by the data bus. No data formatting or encoding is required for MAF.

3.2.1.1.1 Data Bus Commanding - Forward service type, data rate, and Shuttle mode (if applicable) are provided in the MDP_SPECIFIC_CONFIGURATION_COMMAND.

3.2.1.2 Data Presence Monitoring - The unit shall monitor the input forward user data and clock inputs for data presence. Data presence shall be reported in the MDP_PERFORMANCE_REPORT if 20 percent or greater transition density was measured for every interval of 1,600 clock cycles, sampled once per second. Otherwise, data absence shall be reported. Data presence indications may not be valid if the input data clock is clamped.

3.2.1.3 Data Clamping - When the input data clock is clamped to a Logical-1 State, the unit shall inhibit data modulation of the carrier. PN modulation will continue unless it has been explicitly inhibited. The unit does not provide status as to whether data is clamped or not.

3.2.1.4 PN Code Generation - The unit shall be capable of generating the following types of PN codes as specified in STDN No. 108:

a. Command Channel Code - The Command Channel Code, when required, shall be applied to the I channel of the modulator. Note that for K-Shuttle forward services, only the Command Channel Code (i.e., the short code) is applied to the carrier; there is no Range Channel for KSHF.

b. Range Channel Code - The Range Channel Code, when required, shall be applied to the Q channel of the modulator.

c. Shuttle S-Band Forward Link Code - The Shuttle S-Band Forward Link Code, when required, shall be applied to the I channel of the modulator and shall only be used when the modulator is configured for BPSK modulation.

d. Mode 1 Return Link Codes - Mode 1 Return Link Codes are used for Range Zero Set. See 3.2.1.7, Tracking Services.

e. Additional details - The relationships between Command Channel Code and Range Channel Code, the length of shift registers, the details of feedback taps, and so forth; these details shall all satisfy the requirements of STDN No. 108.

3.2.1.4.1 PN On/Off - The unit shall respond to commands from the data bus to turn PN modulation on or off.

a. PN inhibited - PN modulation off is equivalent to PN modulation inhibited. When PN is inhibited, the unit shall BPSK modulate the carrier. That is, the Q channel shall be suppressed when PN is inhibited.

b. Explicit commanding required - The unit does not determine whether PN modulation is appropriate for the configured service. The unit responds explicitly to commands from the data bus.

3.2.1.4.2 PN Modulation - When PN modulation is required, the PN code applied to the I channel PN code shall be modulo-2 added to the I channel symbol stream after all data formatting and encoding has been accomplished. The modulo-2 sum shall then be applied to the I channel. The Q channel PN code shall be applied directly to the Q channel; data is not permitted on the Q channel for forward user services.

3.2.1.4.3 PN Rate - The nominal PN rate for forward services, with the exception of S-Shuttle, is approximately 3 Mcps (cps = chips per second). The nominal S-Shuttle PN rate is 11.232 Mcps, tunable over plus or minus one percent. The actual PN rate is as specified in 3.2.1.6, Carrier Frequency and PN Chip Rate.

3.2.1.4.4 PN Code Epoch Synchronization - Except for Range Zero Set, the MDP shall always synchronize the Range Channel PN code such that its epoch is aligned to within $\pm$25 nanoseconds of the CTFS 1 PPS mark corresponding to the EFFECTIVE TIME of the MDP_START_SERVICE_COMMAND.

a. Range Zero Set - For Range Zero Set, the code used on the I channel shall be synchronized such that its epoch is aligned to within $\pm$25 nanoseconds of the CTFS 1 PPS mark corresponding to the EFFECTIVE TIME of the MDP_START_SERVICE_COMMAND.

b. Shuttle Services - PN codes used for S-Shuttle and K-Shuttle forward services do not require epoch synchronization.

3.2.1.4.4.1 Effect of PN Modulation Inhibit/Enable on Epoch Synchronization - Following an MDP_START_FWD_SERVICE_COMMAND, if PN modulation is inhibited and then subsequently enabled, the PN epoch synchronization requirement of 3.2.1.4.4 still applies (i.e., the PN code state will be exactly the same as if PN modulation had been enabled the entire time). This includes the case where PN modulation is initially configured as inhibited when the MDP_START_FWD_SERVICE_COMMAND is received.

3.2.1.4.5 Data Bus Commanding - Initial register values and feedback taps for PN generators are provided in the MDP_SPECIFIC_CONFIGURATION_COMMAND. PN modulation on/off and PN chip rate are given or derived from the MDP_COMMON_CONFIGURATION_COMMAND. PN code synchronization is controlled by the MDP_START_FWD_SERVICE_COMMAND.

3.2.1.5 PSK Modulation - The unit shall provide binary phase shift keying (BPSK) or unbalanced quadrature phase shift keying (UQPSK) modulation as specified.

3.2.1.5.1 Modulation Requirements by Service - The following specifications define the modulation requirements for each service:

a. SSA Forward - SSAF services are UQPSK modulated when PN modulation is on, and BPSK modulated when PN modulation is off.

b. SSH Forward - SSHF services are BPSK modulated. PN modulation may be on or off.

c. KSA Forward - KSAF services are UQPSK modulated when PN modulation is on, and BPSK modulated when PN modulation is off. PN modulation will always be commanded off by the bus controller for data rates greater than 300 kbps.

d. KSH Forward - KSHF services are BPSK modulated. PN may be on or off.

e. MA Forward - MAF services are UQPSK modulated when PN modulation is on, and BPSK modulated when PN modulation is off.

f. Range Zero Set - RZS services are UQPSK modulated with PN modulation on the I Channel and no modulation on the Q Channel. See 3.2.1.7.2, Range Zero Set (RZS).

3.2.1.5.2 Modulator Performance - The unit shall satisfy the following signal parameters and constraints for modulator performance. The definitions for signal parameters are as described in STDN No. 101.2 Revision 6, STGT-HE-06-2, but are referenced to the MDP output (as opposed to HPA output referenced in STDN No. 101.2).

a. I and Q channels - The UQPSK modulator in phase channel (I) shall be the Command Channel. The quadrature channel (Q) shall be the Range Channel. The I channel carrier shall lead the Q channel carrier by 90 degrees.

b. I:Q power ratio - The Command Channel to Range Channel power ratio shall be 10 dB, $\pm$0.5 dB.

c. Modulator gain imbalance - For UQPSK and BPSK modulation, the peak modulator gain imbalance shall be less than or equal to .25 dB.

d. I:Q phase relationship - The relative peak phase between Command and Range channels shall be 90 degrees, +/- 3 degrees.

e. Data asymmetry - The peak value for data asymmetry contributed by the MDP shall be +/- 3 percent, assuming the input data to the MDP is perfect.

f. Data transition time - The unit's contribution to data transition time shall be less than 5 percent of a data bit time, except for KSAF. For KSAF the data transition time shall be less than the greater of 4 nanoseconds or 5 percent of a bit duration.

g. Phase non-linearity - Peak phase non-linearity shall be $\leq$ 1.5 degrees for the following reference bandwidths:

(1) UQPSK +/- 7.0 MHz
(2) BPSK +/- 17.5 MHz

h. Gain flatness - The peak deviation from gain flatness shall be $\leq$ 0.15 dB for the following reference bandwidths:

(1) UQPSK +/- 7.0 MHz
(2) BPSK +/- 17.5 MHz

i. Gain slope - The peak gain slope shall be ≤ +/- 0.15 dB over any 3 MHz band for the following reference bandwidths:

(1) UQPSK +/- 7.0 MHz
(2) BPSK +/- 17.5 MHz

j. PN code jitter - The RMS PN code chip jitter shall be ≤ one degree, including the effects of Doppler compensation.

k. Data bit jitter - The peak data bit jitter contributed by the MDP shall be ≤ 0.5 percent, assuming the input data to the MDP is perfect.

l. Spurious phase modulation (PM) - The RMS spurious phase modulation shall be ≤ 0.8 degrees over the reference bandwidths:

(1) UQPSK +/- 10.0 MHz
(2) BPSK +/- 25.0 MHz

m. Incidental amplitude modulation (AM) - The peak incidental amplitude modulation shall be ≤ 1.4 percent over the reference bandwidths:

(1) UQPSK +/- 10.0 MHz
(2) BPSK +/- 25.0 MHz

n. Phase noise - The total RMS phase noise, added to the input CTFS phase noise:

(1) UQPSK and BPSK

1 Hz to 10 Hz 0.1 degrees, maximum
10 Hz to 32 Hz 0.1 degrees, maximum
32 Hz to 1 kHz 0.1 degrees, maximum

(2) UQPSK

1 kHz to 10 MHz 0.1 degrees, maximum

(3) BPSK

1 kHz to 25 MHz 0.1 degrees, maximum

o. PN code chip skew, I:Q - The peak skew between Command and Range channel PN codes shall be ≤ 0.01 chip.

p. PN code chip asymmetry - The peak PN code chip asymmetry shall be ≤ 0.01 chip.

q. PN code chip rate relative to carrier - The peak PN code chip rate relative to absolute coherence with the carrier rate (except for SSHF) shall be ≤ 0.01 chips per second at the PN code chip rate.

r. Carrier suppression - Carrier suppression shall be 30 dB, minimum.

s. Signal to thermal noise ratio - The signal to thermal noise ratio in the reference 3 dB bandwidth shall be 50 dB, minimum:

(1) UQPSK +/- 10.0 MHz
(2) BPSK +/- 25.0 MHz

3.2.1.5.3 Start of Modulation - The MDP shall begin modulation of the IF carrier by PN code and data, as applicable, at the CTFS 1PPS mark corresponding to the EFFECTIVE TIME of the MDP_START_SERVICE_ COMMAND.

3.2.1.6 Carrier Frequency and PN Chip Rate - This section specifies the performance requirements for the MDP IF carrier frequency, $f_{MDP}(t)$, and the PN chip rate, $r_{MDP}(t)$, generated by the MDP. Carrier frequency and PN chip rate are affected by Doppler compensation, user frequency and service assignment, and by user acquisition assistance. The MDP IF carrier and PN code clock shall be coherently derived from the CTFS 10 MHz reference.

3.2.1.6.1 General Form for $f_{MDP}(t)$ - The MDP shall generate an IF carrier frequency given by:

$$f_{MDP}(t) = K_1 + K_2 + a(t) \qquad [3.1]$$

where: K_1 = base frequency, $K_1 = 370.\bar{0}$ MHz

K_2 = FORWARD IF OFFSET FREQUENCY, df_F

$a(t)$ = altered profile

3.2.1.6.1.1 Base Frequency, K_1 - The base frequency is a constant value for all services (SSA, SSH, KSA, KSH, and MA). It is defined to be $370.\bar{0}$ MHz, where the overbar indicates that the final zero is repeated to the accuracy of the CTFS 10 MHz reference. This constant is always applied to equation 3.1.

3.2.1.6.1.2 FORWARD IF OFFSET FREQUENCY, K_2 - The FORWARD IF OFFSET FREQUENCY is a constant. It is used to accommodate user service and frequency assignment. This constant is always applied to equation 3.1.

a. Range of values - The range of values for FORWARD IF OFFSET FREQUENCY is:

SSA	- 750 kHz to - 250 kHz
KSA	- 700 kHz to + 700 kHz
MA	+ 1,300 kHz to + 1,500 kHz

b. Data bus messages - The value for FORWARD IF OFFSET FREQUENCY is provided in the MDP_COMMON_CONFIGURATION_ COMMAND. It includes the effects of both service assignment and frequency assignment.

c. Default value - There is no specific default value for the FORWARD IF OFFSET FREQUENCY. The value applied to equation 3.1 by the unit is, however, reported in the MDP_COMMON_ CONFIGURATION_REPORT.

3.2.1.6.1.3 Altered Profile

a. General Form of a(t) - The unit shall compute and apply the altered profile, a(t), in accordance with the following equation:

$$a(t) = A(t)*df_{DC}(t) + B(t)*f_{SWEEP} + C(t)*STEPSIZE + D(t)*f_{TARGET}(t) \qquad [3.2a]$$

where

$df_{DC}(t)$ = Commanded Doppler profile, described in para. 3.2.1.6.1.3.1 below,

$f_{SWEEP}(t)$ = Forward link sweep function, described in para. 3.2.1.6.1.3.2.d below,

STEPSIZE = Step size parameter of the MDF_FWD_DOPPLER_COMP_CONTROL_COMMAND, described in para. 3.2.1.6.1.3.3.b below,

$f_{TARGET}(t)$ = Target frequency function, described in para. 3.2.1.6.1.3.4.e below,

and A(t), B(t), C(t), and D(t) are binary coefficients, valued either 0 or 1, used to turn the profile and its modifying functions on or off.

b. Values of Binary Coefficients at Service Starts - The unit shall set the beginning of a service, i.e., at the execution time of the MDP_START_SERVICE_COMMAND, as follows:

$$B(t) = 0 \qquad [3.2b]$$

$$C(t) = 0 \qquad [3.2c]$$

$$D(t) = 0 \qquad [3.2d]$$

A(t) in accordance with the value of INITIAL_DOPPLER_COMPENSATION_CONFIGURATION commanded in the MDP_COMMON_CONFIGURATION_COMMAND:

$$A(t) = \begin{cases} 1 & \text{if Compensation Enabled} \\ 0 & \text{if Compensation Inhibited} \end{cases} \qquad [3.2e]$$

3.2.1.6.1.3.1 Doppler Profile - The Doppler profile will be provided by the Control HWCI in the MDP_EPHEMERIS_DATA_COMMAND. The profile is provided in the form of a table of frequency values spaced at 0.5 second intervals aligned with the epochs of the CTFS 1 PPS. Linear interpolation between values shall be assumed. The table is named, DOPPLER COMPENSATION TABLE. It is not always applied to equation 3.1.

a. Capacity - The unit shall be capable of storing up to 50 minutes of profile data.

b. Limits - The profile will conform to the limits given in table XIII.

c. Profile updating - The unit shall be capable of updating or overwriting stored profile data without affecting performance. Newly supplied profile data shall be implemented no later than 10 seconds after receipt.

3.2.1.6.1.3.2 Sweep Function - The sweep function is used to assist the USAT acquire the forward link by slowly sweeping the transmitted forward link signal through the frequency uncertainty range of the user transponder. Shuttle services do not require the sweep function.

a. Data bus message - The unit shall perform this function in response to an MDP_FORWARD_FREQUENCY_SWEEP_COMMAND.

b. Effective time - Effective time, T_E, is the time at which the sweep function shall begin. The effective time will always correspond to an epoch of the CTFS 1 PPS. The time will always correspond to an epoch of the CTFS 1 PPS and will always be at least one second later than the time when the MDP_FREQUENCY_SWEEP_ COMMAND is received.

c. Control of Binary Coefficient B(t) - In response to the MDP_FORWARD_FREQUENCY_SWEEP_ COMMAND, the unit shall set the value of the binary coefficient B(t) to unity, beginning at the effective time.

d. Form of $f_{SWEEP}(T)$ - The linear ramp shall have a starting value of -S at the effective time, and a final value of +S at the final value time, exactly 120 seconds later. Values for S are constants as defined below:

(1) For SSA and MA - The linear ramp shall have a starting value of -3,094 Hz at the effective time and a final value of +3,094 Hz. So that for SSA and MA, S = 3,094 Hz (an integer value).

(2) For KSA - The linear ramp shall have a starting value of -30,849 Hz at the effective time and a final value of +30,849 Hz. So that for KSA, S = 30,849 Hz (an integer value).

(3) In general form:

$$f_{SWEEP}(t) = \begin{cases} (1+BIAS)*S + 2*S*(t-T_E)/120 & \text{for } T_E \le t \le T_E+120 \\ S & t > T_E+120 \end{cases} \quad [3.3]$$

where

BIAS equals zero if this is the first sweep after execution of an MDP_START_SERVICE_COMMAND or MDP_FWD_DOPPLER_COMP_CONTROL_ COMMAND, or unity otherwise.

e. Subsequent sweep commands - Subsequent MDP_FWD_FREQUENCY_SWEEP_ COMMANDS shall cause equation 3.3 to be implemented at the new effective time.

3.2.1.6.1.3.3 Break Lock Function - The break lock function is used to break lock on the forward link when it is suspected that the user transponder has false locked. The break lock command causes the unit to effect an abrupt frequency change in the IF carrier frequency, thus knocking the user transponder off the false lock point.

a. Data bus message - The unit shall execute this function in response to an MDP_FORWARD_ BREAK_LOCK_COMMAND. The message shall provide a STEP SIZE, a DURATION, and an effective time (EFFECTIVE TIME HOURS, EFFECTIVE TIME MINUTES, EFFECTIVE TIME SECONDS).

b. Step size - The value for STEP SIZE, provided by the data bus will be of a value such that $f_{MDP}(t)$ does not go outside of the range:

SSA	369.5 MHz	+/- 335 kHz
KSA	370.0 MHz	+/- 1.260 MHz
MA	371.4 MHz	+/- 185 kHz

The value for STEP SIZE will be an integer value resolved to units of 1 kHz.

c. Duration - The value for DURATION shall be an integer value between 1 and 120, resolved to units of one second.

d. Effective time - Effective time, T_E, is the time at which the break lock function shall begin. The time shall always correspond to an epoch of the CTFS 1 PPS and shall always be at least one second later than the time when the MDP_FORWARD_BREAK_LOCK_COMMAND is received.

e. Response to Command - In response to the MDP_FORWARD_BREAK_LOCX_COMMAND, the unit shall adjust the values of the binary coefficients A(t) and C(t) as follows:

$$A(t) = \begin{cases} 0 & \text{for } T_E < t \leq T_E + \text{DURATION} \\ A(T_E) & \text{for } t > T_E + \text{DURATION} \end{cases} \quad [3.4a]$$

$$C(t) = \begin{cases} 1 & \text{for } T_E < t \leq T_E + \text{DURATION} \\ 0 & \text{for } t > T_E + \text{DURATION} \end{cases} \quad [3.4b]$$

3.2.1.6.1.3.4 Target Frequency - This function is used to effect smooth transitions between Doppler compensation on and off. The unit shall execute this function in response to an MDP_FWD_DOPPLER _COMP_COMMAND which will provide the following parameters:

a. Duration, D - The duration shall be an integer value between 1 and 120 seconds.

b. Effective time, T_E - The effective time will always correspond to an epoch of the CTFS 1 PPS, and will always be at least one second later than the time when commanded.

c. Delta Target Frequency, df_{FT} - The Delta Target Frequency will be within the following range:

(1) For SSAF and SSHF - The Delta Target Frequency will be within the range -85 kHz to +85 kHz.

(2) For KSAF and KSHF - The Delta Target Frequency will be within the range -560 kHz to +560 kHz.

(3) For MAF - The Delta Target Frequency will be within the range -85 kHz and +85 kHz.

d. Return to Profile (RTP) - This is the value of the parameter RETURN TO PROFILE AFTER ENABLE SWEEP in the MDP_FWD_DOPPLER_COMP_CONTROL_COMMAND; a logical value, either True (Yes) or False (No).

e. Form of $f_{TARGET}(t)$ - This function is a linear ramp from the existing value of the altered profile at the effective time to the target frequency DURATION seconds later:

$$f_{TARGET}(t) = \begin{cases} a(T_E) + [df_{FT} - a(T_E)] * (t-T_E)/\text{DURATION}, & \text{for } T_E < t \leq T_E + \text{DURATION} \\ df_{FT} & \text{for } t > T_E + \text{DURATION} \end{cases} \quad [3.4c]$$

f. Control of Binary Coefficients - In response to the MDF_FWD_DOPPLER_COMP_CONTROL_COMMAND, the unit shall adjust the coefficients A(t), B(t), and D(t) as follows:

$$A(t) = \begin{cases} 0 & \text{for } T_E < t \leq T_E + \text{DURATION} \\ 1 & \text{for } t > T_E + \text{DURATION, if RTP = YES} \\ 0 & \text{for } t > T_E + \text{DURATION, if RTP = NO} \end{cases} \quad [3.4d]$$

$$D(t) = \begin{cases} 1 & \text{for } T_E < t \leq T_E + \text{DURATION} \\ 0 & \text{for } t > T_E + \text{DURATION, if RTP = YES} \\ 1 & \text{for } t > T_E + \text{DURATION, if RTP = NO} \end{cases} \quad [3.4e]$$

$$B(t) = 0 \quad \text{for } t > T_E \quad [3.4f]$$

3.2.1.6.1.3.5 Active Commands - The bus controller will not activate more than one altered profile command at a time. For example, commands to break lock will not be sent during a frequency sweep. Control commands are active during the time between the effective time T_E, and T_E + DURATION.

3.2.1.6.2 Carrier Frequency Adjustment - The unit shall implement all commanded variations in IF carrier frequency with a series of phase continuous frequency steps that meet the following requirements:

a. Update rate - The unit shall be capable of a stepping rate of 500 steps per second, minimum.

b. Accuracy - The unit shall follow commanded variations to an accuracy of +/- 0.8 Hz when the commanded variations conform to table XIII.

3.2.1.6.3 General Form for $r_{MDP}(t)$, Except S-Shuttle Except for S-Shuttle services, the PN code chip rate, $r_{MDP}(t)$, shall be generated directly from the IF carrier frequency. Adjustments to PN chip rate shall be coherent with the adjustments to the IF carrier in accordance with the following:

$$r_{MDP}(t) = [f_{MDP}(t) + K_3] * M/(N * P) \quad [3.5]$$

where: K_3 = zero-motion FORWARD TRANSLATION FREQUENCY, f_d

M = 31, a constant

N = 96, a constant

P = 221, a constant for SSA and MA forward

P = 1,469, a constant for KSA and KSH forward

3.2.1.6.3.1 Forward Translation Frequency - The FORWARD TRANSLATION FREQUENCY is provided by the Control HWCI in the MDP_COMMON_CONFIGURATION_COMMAND. It is related to the zero-motion USER RECEIVE FREQUENCY by the following equation. Zero-motion means no relative motion between SVST and the Tracking and Data Relay Satellite (TDRS) and no motion between TDRS and the user spacecraft (USAT); an arbitrary condition.

$$\text{USER RECEIVE FREQUENCY} = K_1 + K_2 + K_3 \quad [3.6]$$

3.2.1.6.3.2 Constants M, N, and P - M, N, and P are integer constants. M and N are fixed for all services. P is determined by service configuration as indicated in equation 3.5.

3.2.1.6.4 General Form for $r_{MDP}(t)$ for S-Shuttle - The S-Shuttle PN code chip rate is independent of the IF carrier frequency. The general equation for the S-Shuttle PN code chip rate is:

$$r_{MDP}(t) = R * [f_o + a'(t)] \qquad [3.7]$$

where:

R = ratio of zero-motion PN chip rate to zero-motion USER RECEIVE FREQUENCY

$R = r_o/f_o$

r_o = zero-motion PN chip rate

f_o = zero-motion USER RECEIVE FREQUENCY

$f_o = K_1 + K_2 + K_3$

$a'(t)$ = altered profile, relative to PN chip rate

3.2.1.6.4.1 The Ratio, R - The ratio, $R = r_o/f_o$ is used as a reference.

a. Value for r_o - The zero-motion PN chip rate is provided in the MDP_SPECIFIC_CONFIGURATION_COMMAND as SSHF PN CODE RATE.

b. Value for f_o - The zero-motion USER RECEIVE FREQUENCY is determined from data provided in the MDP_COMMON_ CONFIGURATION_COMMAND as described in 3.2.1.6.3.1.

3.2.1.6.4.2 Altered Profile for S-Shuttle PN - The altered profile for S-Shuttle PN, a'(t), is identical to the previously defined altered profile, a(t), except that control and command of the profile is with respect to the S-Shuttle PN and the sweep function is not used. Specifically,

a. In the INITIAL_DOPPLER_COMPENSATION_CONFIGURATION parameter of the MDP_COMMON_CONFIGURATION_COMMAND, the field "Fwd PN Doppler Compensation Active" shall control a'(t) in the same way the field "Compensation Enabled" controls a(t).

b. In the MDP_FORWARD_DOPPLER_COMP_CONTROL_COMMAND, the parameter COMMAND_WORD indicates whether the command applies to a(t), a'(t), or both:

(1) If the field "Ramp Carrier Frequency" is set to 1, then the command shall be applied to a (t).

(2) If the field "Ramp PN Code Rate" is set to 1, then the command shall be applied to a'(t).

c. The MDP_FORWARD_BREAK_LOCX_COMMAND shall always be applied to both a(t) and a'(t).

d. The MDP_START_SERVICE_COMMAND shall always be applied to both a (t) and a'(t).

3.2.1.6.4.3 Carrier and Code Are Independent - The altered profiles for carrier and code shall be applied independently for S-Shuttle.

3.2.1.7 Tracking Services - The unit shall provide support for Time Transfer Measurement and Range Zero Set.

3.2.1.7.1 Time Transfer Measurement - For configurations when the Range Channel Code is active the unit shall measure and report the time from each CTFS 1 PPS epoch to the next epoch of the Range Channel Code.

a. Services - The measurement is only required for services when the Range Channel Code is enabled. It is not required for Shuttle or Range Zero Set services.

b. Resolution - The measurement shall be resolved to a resolution of 100 nanoseconds.

c. Random error - The RMS random error shall not exceed 100 nanoseconds.

d. Systematic error - The systematic error in repeated trials of Time Transfer Measurement shall be 10 nanoseconds with a maximum variation of plus or minus 10 nanoseconds. That is, the measurements may have a positive bias of up to 10 nanoseconds with an additional +/- 10 nanoseconds of error about the bias point.

e. Data bus messages - The Time Transfer Measurement shall be provided in the MDP_TIME_TRANSFER_REPORT. The report shall be available for collection by the data bus during the entire period from 1,300 to 2,000 milliseconds following the CTFS 1 PPS reference epoch against which the measurement was made. The time tag on the measurement shall be one second later than the time of the CTFS 1 PPS reference epoch.

3.2.1.7.2 Range Zero Set (RZS) - To support Range Zero Set, the unit shall UQPSK modulate the carrier with the same parameters and constraints as specified in 3.2.1.5.2, Modulator Performance. However, the Range Channel Code shall be applied to the in phase (I) channel and no modulation (data or PN) shall be applied to the quadrature (Q) channel. That is, the Q channel shall consist of carrier only.

a. PN codes - Mode 1 Return Link Codes may be used in place of the Range Channel Code. This is transparent to the unit since the MDP's PN code generators are controlled by the RANGE CHANNEL FEEDBACK TAPS in the MDP_SPECIFIC_ CONFIGURATION_COMMAND sent by the data bus.

b. Data clamped - Input data from the Primary Interface will be clamped to a logical-1 by the GE controlled configuration items when Range Zero Set is required.

c. RZS PN code chip rate - The PN code chip rate shall be as specified in 3.2.1.6.2 Relationship between Carrier Frequency and Chip Rate. Only the values for base frequency, K_1, and FORWARD IF OFFSET FREQUENCY, K_2, will be applied to equation 3.1.

d. Frequency control prohibited - While configured for Range Zero Set, the bus controller will not send the following frequency control commands:

(1) MDP_FORWARD_FREQUENCY_SWEEP_COMMAND
(2) MDP_FORWARD_BREAK_LOCK_COMMAND
(3) MDP_FORWARD_DOPPLER_COMP_CONTROL

e. Data bus messages - Range Zero Set is configured by the MDP_SPECIFIC_CONFIGURATION_COMMAND by setting SERVICE TYPE and providing RANGE CHANNEL FEEDBACK TAPS. The MDP_ START_FORWARD_ SERVICE_COMMAND supplies forward PN epoch time and initiates modulation.

f. PN Synchronization - As specified in 3.2.1.4.4.1.

3.2.1.8 Performance Monitoring
The unit will provide performance monitoring functions in support of operational performance monitoring and to support maintenance.

3.2.1.8.1 Confidence Test - The unit shall provide a self-test capability which shall provide initial confidence in the unit. The test shall be run whenever the unit is initially powered up, or when commanded, and shall include the following:

a. Local/remote control - The test shall be initiated upon power up, by local control, or upon remote command.

(1) Local control - The unit shall run Confidence Test when the Reset Switch located on the Maintenance Panel is depressed, regardless of whether the Local/Remote switch is in Local or Remote position.

(2) Remote Control - When the Local/Remote switch is in the Remote position, the unit shall run Confidence Test upon receipt of the MDP_SET_STATE_COMMAND, with the INITIALIZATION TYPE set to RESET.

(3) Local/Remote status - The unit shall provide the status of the local/remote control to the data bus via the MDP_PERFORMANCE_REPORT.

3.2.1.8.1.1 Performance Requirements - The Confidence Test shall:

a. Detect failures - The Confidence Test shall detect hard failures of power supplies and microprocessors for at least 95 percent of all failure modes, weighted for failure rate.

b. Report failures - When a malfunction is detected, data concerning the malfunction shall be entered into temporary storage for later recall by the data bus via the MDP_EXTENDED_BIT_REPORT.

c. False alarm - The Confidence Test shall have a maximum false alarm rate of one percent.

d. Test time - The time between initiation of the Confidence Test and the availability of test results via the data bus shall not exceed 10 seconds.

3.2.1.8.1.2 Additional Tests - To support maintenance and operation, the unit shall provide built-in tests (BIT), including On-line BIT Test and Extended BIT.

3.2.1.8.1.2.1 On-Line BIT - On-line BIT is a continuous process that is run on all active MDP states, which includes:

a. Monitor automatic level controls (ALC)
b. Monitor synthesizer lock
c. Monitor 1 PPS
d. Monitor environment
e. Monitor time
f. Monitor exceptions

On-line BIT test results shall be provided in the MDP_PERFORMANCE_ REPORT.

3.2.1.8.1.2.2 Extended BIT - Extended BIT is, as its name suggests, a more extended BIT is run when the unit is not supporting active user services.

a. Local Control - When the unit is under Local Control, Extended BIT shall run when the front panel switch, BIT INITIATE, is depressed. Test results shall be available in the MDP_EXTENDED_ BIT_REPORT, and by examining status indicators on the applicable LRUs inside the unit.

b. Remote Control - When the unit is under Remote Control, this test shall run in response to the data bus command, MDP_SET_STATE_COMMAND, with the INITIALIZATION TYPE set to RUN EXTENDED BIT. Tests include examination of all major components and other least replaceable units (LRUs). Extended BIT results shall be available in the MDP_EXTENDED_BIT_REPORT.

c. Fault Isolation - Results of Extended BIT shall provide sufficient data to the subsystem controller such that at least 75% of the possible faults identified in FMEA, RMA-02, can be detected and isolated to an LRU or group of LRUs using solely the BIT results and the isolation logic contained in RMA-02.

3.2.1.8.1.2.3 More Performance Data - To support performance monitoring, and to assist in isolation of malfunctions, the unit provides the following additional data in the MDP_PERFORMANCE_REPORT:

a. Error codes - Error codes are provided which provide the reason if the last data bus command was not accepted or executed.

b. Operating state - Several logic states are defined in STGT-HE-06-2 which indicate the operating state of the unit. These are reported, and include:

(1) STANDBY
(2) EXTENDED BIT
(3) CONFIGURED
(4) CONFIGURATION IN PROGRESS
(5) IN SERVICE

c. Delta frequency - The delta frequency from nominal 370 MHz is provided as the DELTA IF FREQUENCY.

d. Ephemeris status - To assist the data bus in the transfer of ephemeris data into the unit, an indication, UPDATE COMPLETE, is provided when the ephemeris update has been accepted by the unit.

e. Frequency control status - The unit's response to commanded frequency control by the data bus is provided.

f. Input data presence - This status information is mandatory, and is as specified in 3.2.1.2, Data Presence Monitoring.

g. PN code state - The unit's response to commanded PN code state is reported.

h. Local/Remote - This status information is mandatory, and is as specified in 3.2.1.8.1.a.(3), Local/remote status.

3.2.1.8.1.2.4 Details of Performance Reports - Additional details of performance reports are provided in STGT-HE-06-2 of this specification.

3.2.2 Physical Characteristics
The unit shall be designed to be housed in a standard 19-inch RETMA rack. The unit shall be provided with slide hardware. Overall geometry and arrangement of major components and units shall provide for easy removal and replacement of units and components to minimize equipment maintenance downtime.

3.2.2.1 Dimensions - The dimensions of this unit are as follows:

a. Panel Height -12.22 +0.00, -0.03 inch
b. Panel Width - 18.97 +0.00, -0.03 inch
c. Chassis Depth - 24 inches, maximum
d. Chassis Width - 17.75 inches, maximum, including slides

3.2.2.2 Weight - The weight of this unit shall not exceed 70 pounds.

3.2.3 Reliability
The unit shall have a minimum mean time between failure (MTBF) goal of 6000 hours when operated in a fixed environmentally controlled area. The MTBF will be calculated using an average temperature of 75 degrees F.

3.2.3.1 Mean Time Between Failures - The MTBF requirements shall apply to the unit while being maintained in accordance with 3.2.4, and during exposure to the environments of 3.2.5. The MTBF shall be analyzed using failure rates based on MIL-HDBK-217, or other sources that are approved by the procuring activity. In order to achieve the required MTBF, the reliability program provisions of STDN 927.4, Section 6 shall apply.

3.2.3.2 Design Life - The unit shall be designed for a lifetime of 10 years of continuous operation, not including administrative periods of non-operation, or downtime for maintenance, as specified in 3.2.4.

3.2.3.3 Acoustical Noise - The acoustical noise level with all fans and/or blowers on, shall be in accordance with MIL-STD-1472 paragraphs 5.8.3.1 and 5.8.3.3.2.

3.2.4 Maintainability
The unit shall meet the maintainability requirements as defined in the following paragraphs.

3.2.4.1 On-Line Replacement - The unit shall be designed to support in-circuit repair or system restoration as defined in 3.5 by fault isolation, disassembly, failed item removal and replacement, reassembly, and test of the replaced unit at the line replaceable unit (LRU) level.

3.2.4.1.1 LRU Level Definition - The LRU level for the unit is board/module, or the unit in its entirety. LRUs shall incorporate status indicators along with test and monitoring points, as appropriate, to allow test via Maintenance Test Group (MTG) test equipment.

3.2.4.2 Mean Time To Repair (MTTR) - The unit shall be designed such that the mean time to achieve on-line repair, including isolation, removal, replacement, and retest of the LRU shall not exceed 25 minutes. In order to demonstrate achievement of the required MTTR, the maintainability verification provisions of STDN No. 927.2, Section 4.4.1.3 shall apply. Logistics time to obtain parts or test equipment is excluded.

3.2.4.3 Maximum Time To Repair (MTR) - The maximum time to effect on-line repair, as defined in 3.5.1.3, shall not exceed one hour for the 90th percentile of failures.

3.2.5 Environmental Conditions

3.2.5.1 Nonoperating Environments - This unit shall suffer no permanent degradation or damage when subjected to the following environments:

a. Temperature - From -20 to 160 degrees F.

b. Humidity - 0 to 100 percent relative humidity, non-condensing environment

c. Altitude - Sea Level to 35,000 feet

d. Solar Radiation - 350 BTU/ft^2/hour

3.2.5.2 Operating Environments - This unit shall meet all specified performance requirements while exposed to the following environments:

a. Temperature - From 50 to 100 degrees F.

b. Humidity - From 20 to 80 percent without condensation

c. Altitude - Sea level to 12,000 feet

3.2.6 Transportability
The equipment shall be capable of shipment by ship, truck, rail and air transport.

3.3 DESIGN AND CONSTRUCTION

Design and construction requirements shall be in accordance with MIL-STD-454 Guidelines, except as specified herein. Commercial equipment such as computers and their peripherals, test equipment, single-board computer boards, and compatible Input/Output (I/O) boards, etc., that meet the performance requirements for use on the program shall be exempt from these requirements.

3.3.1 Materials, Processes, and Parts

3.3.1.1 Materials - Corrosion-resisting materials and finishes shall be used to the maximum extent. Fungus nutrient materials, mercury, and radioactive material shall not be used in any form.

3.3.1.2 Standard and Non-Standard Parts and Materials - Parts and materials shall be selected and fabricated or assembled in such a manner that they conform to these specifications. Non-standard parts and materials as defined shall be used only with the approval of GE Contracts Administration.

3.3.1.2.1 Standard Parts and Materials - Standard parts and materials shall be those specified by any of the following:

a. A published government qualified products list.

b. MIL-STD-975 Grade 2.

c. Commercial specifications certified by the vendor to meet industry specifications and standards as those promulgated by nationally recognized associations, and technical societies as having coordinated status with the government requiring activities.

d. Commercial parts certified by the vendor to meet industry specifications and standards having limited coordination status with the government requiring activities.

3.3.1.2.2 Non-Standard Parts and Materials - Non-standard parts and materials are defined as those being:

a. Selected parts, or those whose performance and physical characteristics are unique when compared with vendor stocked or cataloged items and which cannot be ordered by standard nomenclature only.

b. Any parts and materials not covered by the standard parts and materials definition.

3.3.1.2.3 Standard Components - Standard commercial components shall be employed throughout, to the greatest extent practicable. Sole source components shall be held to a minimum. Unless approved by the GE Contracts Administration, specified performance of the equipment shall be obtained without selection of components whose performance and physical characteristics are unique when compared with vendor stocked or cataloged items and which cannot be ordered by standard nomenclature only.

3.3.1.2.4 Programmable Devices - A firmware document shall be prepared for each unit design requiring firmware. Programmable devices shall be clearly marked and identified.

3.3.1.3 Surface Treatment - All aluminum surfaces shall be chemical-film-treated (iridited) per MIL-C-5541 (Class 3), and MIL-P-53030 Primer before painting. All front panel to cabinet mating surfaces shall be free of paint. Stainless-steel surfaces shall be passivated per MIL-S-5002. Class 1 iridite is permissible when undergoing touch up work.

3.3.1.4 Paint - Panel front and edges, and surfaces exposed when the unit is mounted, shall be painted semigloss gray, Color Chip 26440, per FED-STD-595, with a low volatile organic compound (VOC) polyurethane finish (Cardinal 6400 series). Panel lettering shall be semigloss black chip number 27038.

3.3.1.5 Electrical Grounding and Bonding - Bonding and grounding shall be in accordance with GSFC STDN 270.7. MIL-HDBK-419 shall be used as a reference document. The unit shall have a ground lug located on the rear of the chassis. The lug size shall be either 8/32 or 10/32. The lug (E101) shall provide a ground for the unit.

3.3.1.6 Electrostatic Discharge Protection - Units containing electrostatic discharge (ESD) sensitive devices shall be marked with ESD sensitive device caution labels.

3.3.1.7 Electrical Design

3.3.1.7.1 Electrical Connections

3.3.1.7.1.1 Attachment of Wires and Leads - The equipment shall conform to MIL-STD-454, Requirement 19.

3.3.1.7.1.2 Solderless Wrap - The attachment of wires by solderless wrapping shall conform to MIL-STD-1130.

3.3.1.7.1.3 Soldered Connections - The attachment of wires and leads shall conform to MIL-STD-454, Requirement 5, except resin flux conforming to type RA of QQ-S-571 may be used for electrical and electronic connections. Electrical interconnections and harnesses shall be in accordance with MIL-STD-454 requirements 69 and 71.

3.3.1.7.2 Electrical/Electronic Parts - Electrical/electronic parts shall be selected in accordance with sound engineering practices and in support of the requirements of paragraph 3.2.3. Unless the specific application dictates otherwise, parts shall be of "best commercial quality."

3.3.1.7.3 Electrical Power - The equipment shall operate from the power specified herein.

3.3.1.7.3.1 Single-Phase Power - The unit shall be designed to operate from a two-wire, plus ground, source of 120 volts. The AC power system neutral shall not be connected to the chassis under any circumstances.

3.3.1.7.3.2 Power Transient Susceptibility - Power system transients of as much as a ±10 percent change from the nominal voltage for a period of up to 10 percent of the nominal line frequency, by analysis, will not deteriorate performance of the system. Power transients of a ±10 percent change from the nominal voltage lasting for two (2) seconds shall not prevent satisfactory operation of the equipment immediately following the transient period. Sudden loss of power or prolonged transients of the above type will not damage the equipment.

3.3.1.7.3.3 Overload Protection

a. Electrical overload protection shall meet MIL-STD-454, Requirement 8.

b. A fuse or an overcurrent trip unit of a circuit breaker shall be connected in series with each ungrounded power conductor as determined by the National Electric Code, NFPA 70, for grounded source power.

c. The overcurrent device shall be connected to the line side of the power switch.

3.3.1.7.3.4 Primary Circuit Fuses - There are no primary circuit fuses in this unit.

3.3.1.7.3.5 Circuit Breakers

a. When circuit breakers are used, the restoring or switching device shall be readily accessible to the operator.

b. The circuit breaker shall give a visual indication when the breaker is tripped.

c. Holding the switching device closed on an overload shall not prevent tripping of the breaker.

d. Circuit breakers may be mounted on the rear panel and used as on/off switches.

e. Circuit breakers for DC and single-phase AC applications shall conform MIL-C-39019 or commercial equivalent.

3.3.1.7.4 Printed Wiring - Printed wiring shall meet the requirements of MIL-STD-454, Requirement 17. Conformal coating shall not be applied to the printed-wiring assemblies.

3.3.1.7.5 Single or Double-Sided Printed Wiring Boards - Single or double-sided printed wiring boards shall conform to MIL-P-55110.

3.3.1.7.6 Multilayer Printed Wiring Boards - Multilayer printed wiring boards shall conform to MIL-P-55110.

3.3.1.7.7 Preferred Circuits

a. In the interest of standardization of circuits, use of standards parts and, ultimately, the collection of circuit performance reliability data, circuits shall be selected whose performance is based on parameters of the parts which are controlled by specification.

b. Conversely, circuit performance shall not be dependent on uncontrolled parameters.

c. Selected circuits shall be such that the use of parts having an approximately normal distribution for those characteristics which are important to the individual applications results in the required equipment performance.

3.3.1.8 Mechanical Design

3.3.1.8.1 Accessibility - Access to enclosures shall be in accordance with MIL-STD-454, Requirement 36.

3.3.1.8.2 Structural Integrity - The unit shall be designed to withstand stresses associated with the transportation, installation, operation, and maintenance of the unit.

3.3.1.8.3 Captive Hardware - Captive hardware shall be used to secure any panel or module which normally would be opened or removed as part of a normal maintenance action.

3.3.1.9 Thermal Design - Thermal design shall be in accordance with Requirement 52 of MIL-STD-454.

3.3.2 Electromagnetic Interference (EMI)
The unit shall meet the following EMI requirements at the rack level:

a. CE-03, Radio Frequency Power Line Conducted Emissions -FCC Class A Limits. Appropriate power line filtering shall be used to satisfy the conducted emission and susceptibility requirements.

b. CE-07, Conducted Switching Spikes - MIL-STD-461 reduced to 5 percent of the line voltage during steady state operation and 50 percent at turn on and turn off.

c. CS-01, Audio Frequency Power Lead Conducted Susceptibility (30 Hz -50 kHz) - MIL-STD-461 reduced to 2.5 volts rms from 30 Hz to 13 KHz, then following a straight line to 1.0 volt rms at 50 kHz.

d. CS-02, Radio Frequency Power Line Conducted Susceptibility (.05 to 50 MHz) - MIL-STD-461 reduced to 0.1 volts rms.

e. CS-06, Conducted Spike Susceptibility - MIL-STD-461 reduced to 100 volts peak at 10 microseconds pulse width.

f. RE-02, Radiated Emissions, Electric Field - FCC Class A limit extended down to 15 kHz from 30 MHz, and extended to 10 GHz from 1 GHz with a reduced limit of 20 dBuv/M (measured at 1 meter) from 2.1 to 2.3 GHz. The RE 02 limits specified are granted an additional 20 dB relief due to anticipated rack attenuation.

g. RS-02, Radiated Susceptibility, Magnetic Induction Field, Spikes and Power Frequencies - MIL-STD-461 except reduce the spike voltage to 100 volts peak and power line current (60 Hz) to 2.0 amps.

h. RS-03, Radiated Susceptibility, Electric Fields MIL-STD-461 except reduce the RF field intensity to 0.5 volt/meter from 14 kHz to 2.6 GHz. The RF signal will be amplitude modulated, 50 percent at 400 Hz or 1000 Hz.

3.3.2.1 EMI Development Testing
EMI testing shall include development tests of selected components demonstrating potential problems areas. Development tests or analysis, or both shall be performed to gather and verify the characteristics of the identified potential problem areas. EMI tests shall conform with the methods of MIL-STD-462.

3.3.3 Nameplates and Product Marking
A unit nameplate shall be securely attached to the unit. The identifying nameplates shall be in accordance with requirement 67 of MIL-STD-454. The equipment shall be marked with an identifying number in accordance with MIL-STD-130. Electrical parts shall be labeled with designators where necessary to permit ease of identification and shall be uniform throughout the equipment in accordance with requirement 67 of MIL-STD-454. The CAGE Code shall be used in the identification of the equipment. Commercial equipment shall be identified using vendor's standard practices. Front panel legends shall conform to the criteria of paragraph 5.5 of MIL-STD-1472.

3.3.3.1 Location - The general location for the nameplate shall be not more than six inches behind the front panel. The preferred location is on the right side panel as one views the front to the rear of the unit.

3.3.4 Workmanship
Workmanship of equipment specified herein shall conform to requirement 9 of MIL-STD-454.

3.3.5 Interchangeability/Producibility

3.3.5.1 Interchangeability
Mechanical and electrical interchangeability shall exist between like assemblies, subassemblies, and replaceable parts, regardless of the manufacturer or supplier. The equipment shall be so designed that:

a. Cards and modules normally replaced as part of a maintenance action shall be plug-in design.

b. Replacement of a faulty card and module shall not require the removal of any other card or module.

c. Items with the same identifying part number shall be physically, electrically, and functionally interchangeable.

d. Physically similar, but functionally different cards and modules shall be physically keyed to prevent inadvertent erroneous installation.

e. No card or module replaced as a normal maintenance action shall require alignment or adjustment in the equipment when the replacement is performed, except for power supplies.

3.3.5.2 Producibility - The design shall incorporate features which allow for cost effective production. In this regard, the design shall:

a. Use common materials and processes.

b. Select designs such that automated processes can be used for fabrication.

c. Use multiple sources of supply wherever possible.

d. Use subcontractor standard fabrication, assembly test, and inspection procedures.

3.3.6 Safety
Equipment design shall conform to MIL-STD-454, Requirement 1.

3.3.6.1 Leakage Current - The AC leakage current shall not exceed 5 milliamps (rms), measured at the unit's input AC Power Safety Ground.

3.3.6.2 Power Supply Protection - Fault conditions ranging from open circuits to short circuits shall cause no damage to the power supply.

3.3.6.3 Equipment Electrical Power On-Off Switch

a. A switch for disconnecting the unit from all electrical power systems shall be mounted on the equipment front panel and its function shall be clearly labeled.

b. A locking type power on-off switch shall break all power conductors of the power circuit.

3.3.6.3.1 Printed Circuit Assembly Protection - Transient suppression as well as capacitive decoupling shall be provided on all printed circuit assemblies.

3.3.6.4 Power Indicator - A power indicator shall be connected to the load side of the power switch, across the input power conductors, to indicate that the unit is energized.

3.3.6.5 Electrical Cable Protection - Equipment design shall preclude damage to electrical cabling during all normal conditions of assembly, removal, and insertion of equipment when performed by skilled maintenance personnel.

3.3.6.6 Support Strength

a. Slides, detentes, mounting surfaces and other attachment mechanisms which support equipment shall have a safety factor equal to twice the maximum anticipated load.

b. Drawer slide design shall include provisions to prevent accidental derailing and detachment of equipment from the shelter.

3.3.6.7 Equipment Access

a. Hinged covers, and sides shall have automatic latch/quick release devices which must be actuated before they can be opened.

b. Sufficient clearance shall be provided in each maintenance configuration to allow tasks to be performed without undue physical discomfort, danger, or effort.

3.3.6.8 Critical Controls - Critical controls, the accidental activation of which may cause damage to equipment, injury to personnel or degradation of system function, shall be designed and located so that they are not susceptible of being accidentally activated.

3.3.6.9 Human Error Design Protection - Operator panel control functions shall be designed in such a manner that neither incorrect adjustment nor random sequencing of functions will cause damage to the equipment.

3.3.6.10 Unacceptable Materials - Equipment design shall not include polychlorinated biphenyls (PCBs), asbestos and asbestos compounds, fragile or brittle materials, beryllium and beryllium compounds unless so identified, and lithium and lithium compounds not specifically approved by the procuring agency.

3.3.6.11 Test Circuit Protection - The maintenance panel and front panel test interfaces shall be suitably protected to prevent equipment damage or personnel hazard during maintenance operations.

3.3.7 Human Performance/Human Engineering
Human engineering design criteria and principles shall be applied in equipment design so as to achieve safe, reliable, and effective performance by the operator and maintenance and control personnel. The guidelines of MIL-STD-1472 shall be used as the criteria for human engineering design.

3.4 DOCUMENTATION
The plan for prime item documentation is provided in CC Document No. C901E3331, Configuration Management Plan and Procedures for the Second TDRSS Ground Terminal, also known as IEC CM-01/02.

3.5 LOGISTICS
The unit and its major items shall be designed to include provisions for maintenance in compliance with the reliability, maintainability, and interchangeability requirements of 3.2.3, 3.2.4, 3.3.5 and the concepts and criteria described in the following paragraphs.

3.5.1 Maintenance

3.5.1.1 Adjustments - There shall be no maintenance adjustments on this unit except for power supply voltage level settings.

3.5.1.2 Special Support Equipment - During fault isolation, the Performance Measuring and Monitoring Equipment (PMME) and/or the Maintenance Test Group (MTG) may be required.

3.5.1.3 First Level Maintenance - First level maintenance shall consist of fault detection, fault isolation, including isolation capabilities available with built-in test on line analysis, front panel control, and MTG indicators/test points, followed by removal and replacement of the failed item, reassembly and verification to assure that the system has been restored to operational status. Items replaced during first level maintenance shall be consistent with the line replaceable unit (LRU) concept defined in 3.2.4.1.1.

3.5.1.3.1 Fault Isolation Performance Requirements - The mean time to isolate to an LRU, replacement, and repair inclusive of verification is 25 minutes. The average time to remove and replace an LRU shall not exceed 10 minutes.

3.5.1.3.2 Preventive Maintenance - Preventive maintenance shall be capable of being performed on-line without impeding the operational usage of the unit. Preventive maintenance shall take place with the unit in-place and shall not restrict the usage of the equipment for periods of greate than 1 hour per month.

3.5.1.4 Off-Line Maintenance, Second Level Maintenance - Second level maintenance shall include all repair of failed units or preventive maintenance which is not to be performed in-circuit. Second level maintenance of defective LRUs is normally performed by the vendor's depot facility.

3.6 PERSONNEL AND TRAINING
Refer to CCD # C903F3379.

3.7 MAJOR COMPONENT CHARACTERISTICS
The functional, performance, and physical requirements and characteristics of each major component of this unit are given in the performance specifications referenced in IEC drawing number 7472102.

3.8 PRECEDENCE
The order of precedence with respect to the requirements specified in this document is:

1. This specification, 7472306;
2. With respect to PN codes, STDN.108 to the extent referenced herein;
3. The General Electric specifications as traced in the Traceability Matrix of Appendix II of this document;
4. SOW-GE-STGT-8701, Statement of Work (SOW) for USS SSA Equipment HWCI, KSAR Low Data Rate Equipment HWCI, MA RCVR/XMTR Equipment HWCI. Revision 5, 28 November 1989.

4.0 QUALITY ASSURANCE PROVISIONS

4.1 GENERAL

This section defines the requirements for verification of performance and design characteristics specified in Section 3 of this specification. The subcontractor is required to implement and maintain a quality assurance (QA) program in accordance with the SOW. In the event of conflict between this specification and the SOW, the SOW takes precedence. This program applies to all work accomplished by the subcontractors and suppliers, including subtier sources and other divisions or subsidiaries of the subcontractor who provide parts, materials, components, systems, and software as described in the contract Statement of Work.

The subcontractor shall verify that his procurement documents impose the applicable section of this document on his subcontractors and other suppliers. These subcontractors and other suppliers shall, in turn, impose these standards on their procurement sources.

Verification will include:

a. Inspection (in-coming, in-process and final)

b. Tests

c. Demonstration

d. Analysis

4.1.1 Responsibility for Verifications

Unless otherwise specified in the contract or order, the subcontractor is responsible for the performance of all verification requirements as specified herein. Except as otherwise specified, the subcontractor may utilize his own facilities or any commercial laboratory acceptable to GE. GE reserves the right to perform any of the verifications set forth in the specification where such verifications are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.1.1 Quality Assurance Requirement - Quality assurance requirements shall be in conformance with the Statement of Work (SOW).

4.2 Quality Conformance Verifications

Appendix III defines the method of verification (test, inspection, demonstration, analysis) for each requirement specified in Section 3. All testing shall be performed using calibrated test instrumentation. All data taken during the verification test shall be validated by the subcontractor QA personnel and made available to the GE and NASA QA representative.

4.2.1 Test

Tests identified in Appendix III shall be performed to verify that the hardware conforms to the operational parameters as defined in the applicable paragraph of Section 3. All verification testing shall be performed at ambient conditions. No environmental tests are required.

4.2.2 Inspections

Inspections shall be in accordance with subcontractor's STGT Quality Assurance Plan. Inspections are visual investigations of design, production, or test documentation, or the observation/measurement of hardware/software characteristics to determine compliance with specified requirements. Requirements of Section 3 that are satisfied by inspection are identified in Appendix III.

4.2.3 Demonstration

Demonstrations are the exercise of hardware/software operations to assure that special qualitative functions and capabilities can be performed in accordance with applicable specifications.

4.2.4 Analysis

Where applicable, the verification of some technical parameters and performance will be accomplished by analysis. Analysis is the mathematical treatment including computer analysis of appropriate models to determine compliance with specified requirements where test, demonstration, and inspection are not feasible. Analysis may be performed with as-built test results or as-built data to provide formal verification of a requirement. Analysis shall be documented in SDRL Supporting Engineering Analysis and Data (HE-08).

4.2.5 Method Annotation

An X is placed in the applicable column of Appendix III to mark the verification method for each requirement.

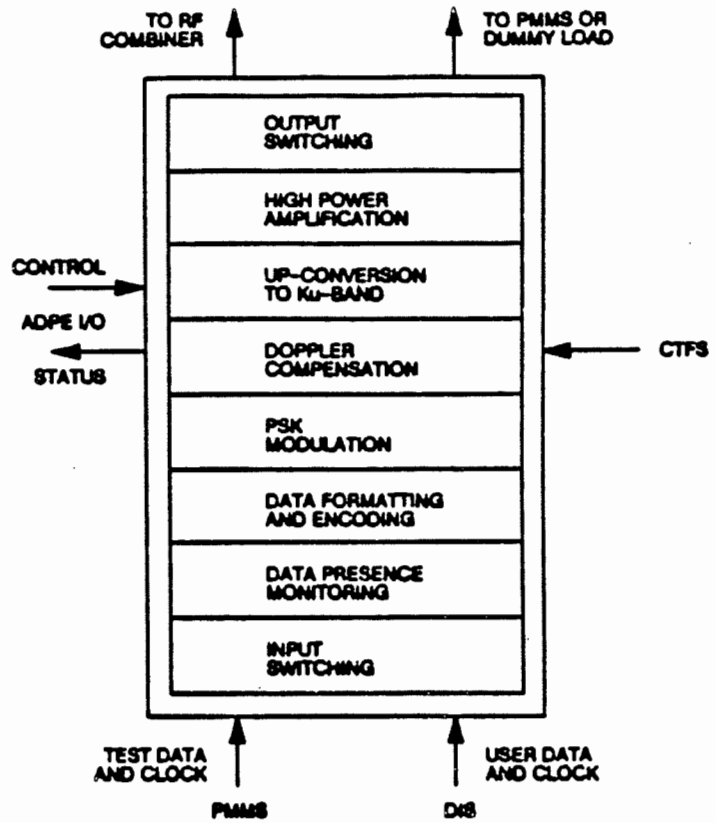
Where an X(P) is placed in one column of Appendix III and an X(S) is placed in one or more of the other columns, this means that the method marked X(P) is the primary verification method, but it must use supporting data gathered from the results of the other methods. An X is placed in the N/A column for Non-Applicable or Non-Requirements such as summary or introductory paragraphs.

5.0 PREPARATION FOR DELIVERY

Preparation for delivery shall be in accordance with NHB.6000.1C. Non-standard practices are not required.

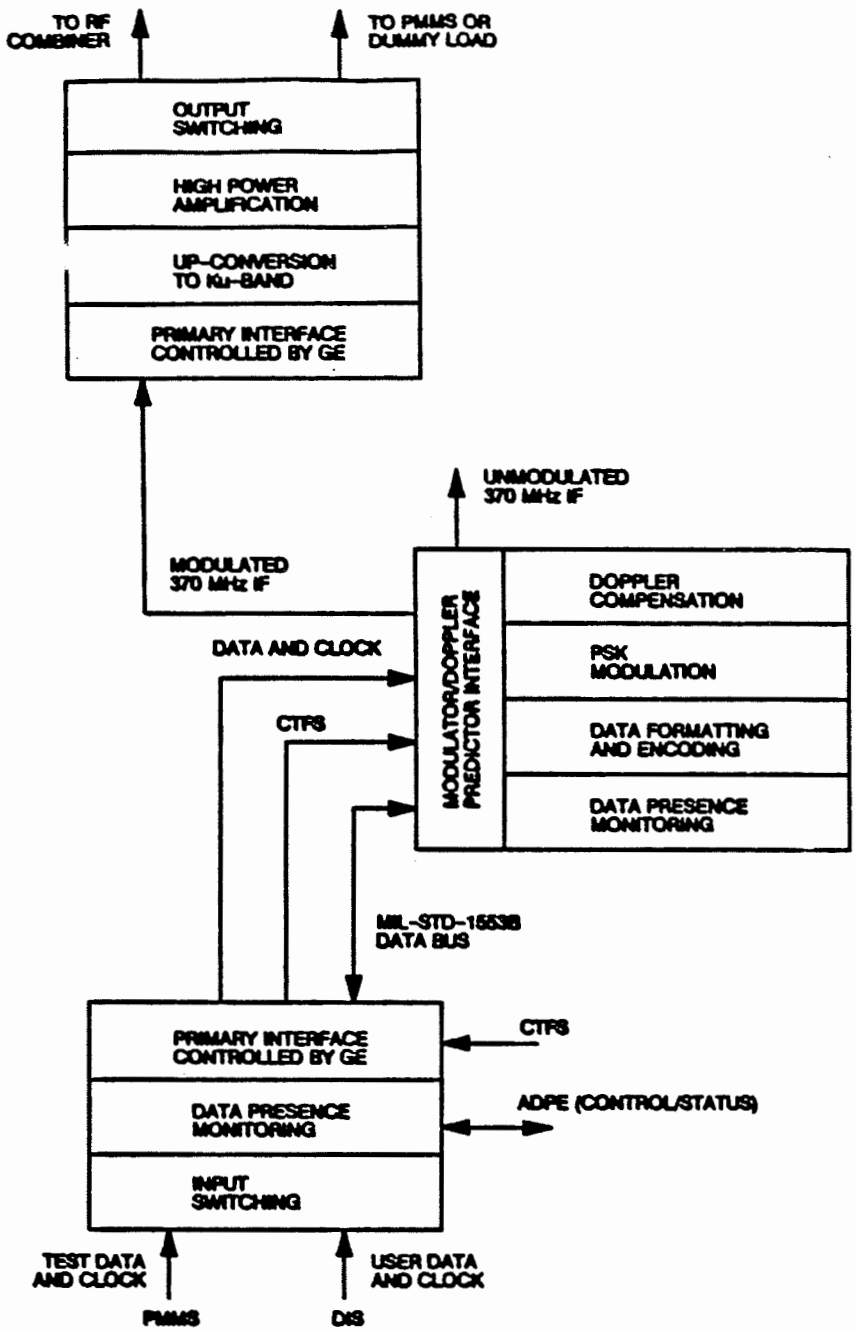
6.0 NOTES

No additional notes or instructions are required.



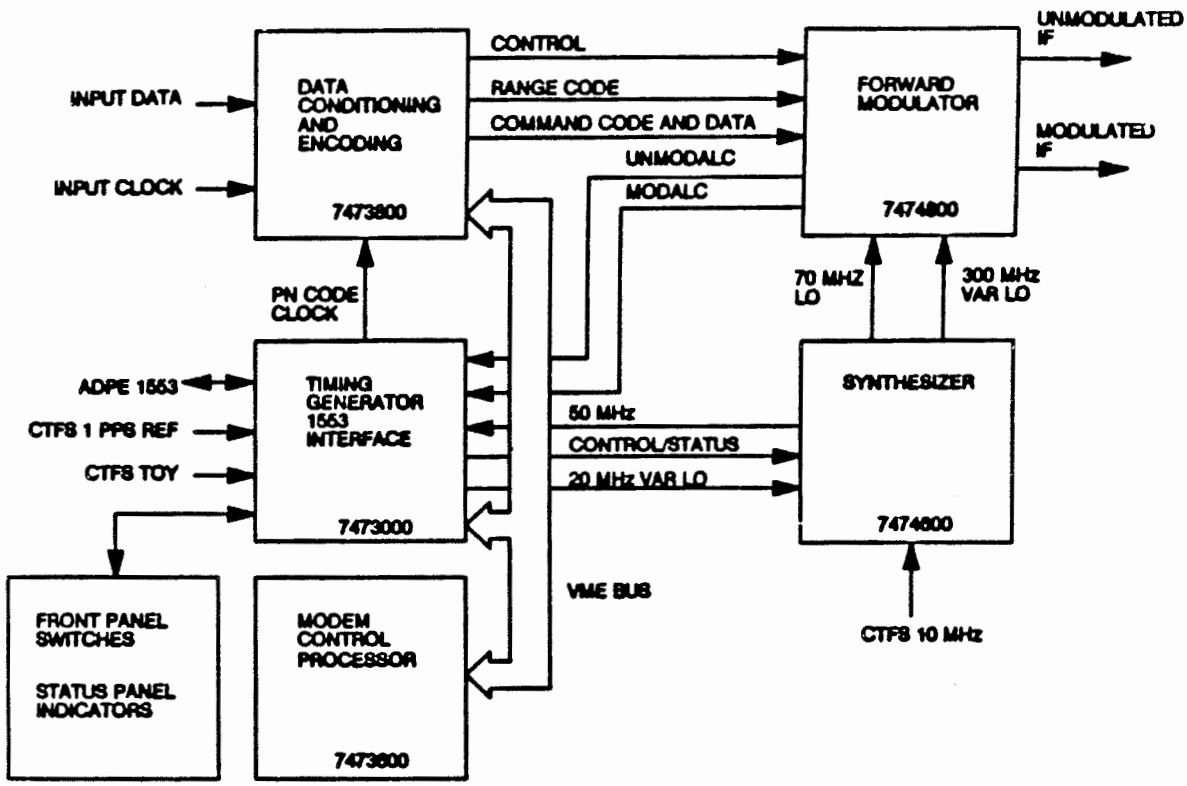
NOTE: The Modulator/Doppler Predictor may be used in any SSA, KSA, or MA USS Forward Service Chain. This figure shows a functional diagram of a generic forward service chain.

Figure 1. USS Forward Service Chain



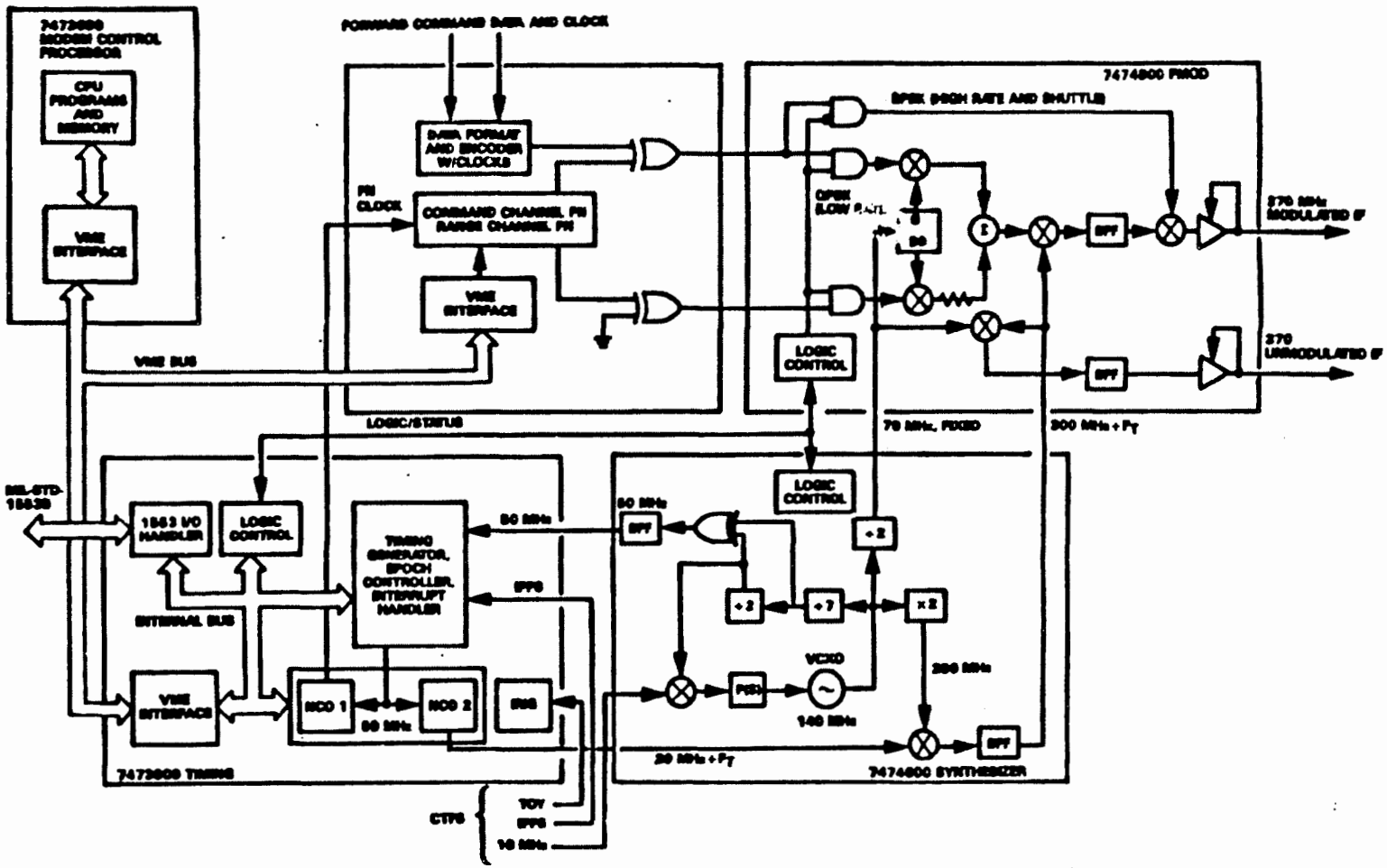
NOTE: This figure illustrates the allocation of forward service chain functions to the MDP. Note that data presence monitoring performed by the MDP is in addition to high level system functions performed elsewhere in the service chain.

Figure 2. Modulator/Doppler Predictor Unit Functions



NOTE: This figure indicates the unit's major components and their general interconnections at the block diagram level.

Figure 3. Unit Block Diagram



NOTE: This figure shows the functional flow among major components of the MDP.

Figure 4. Functional Flow

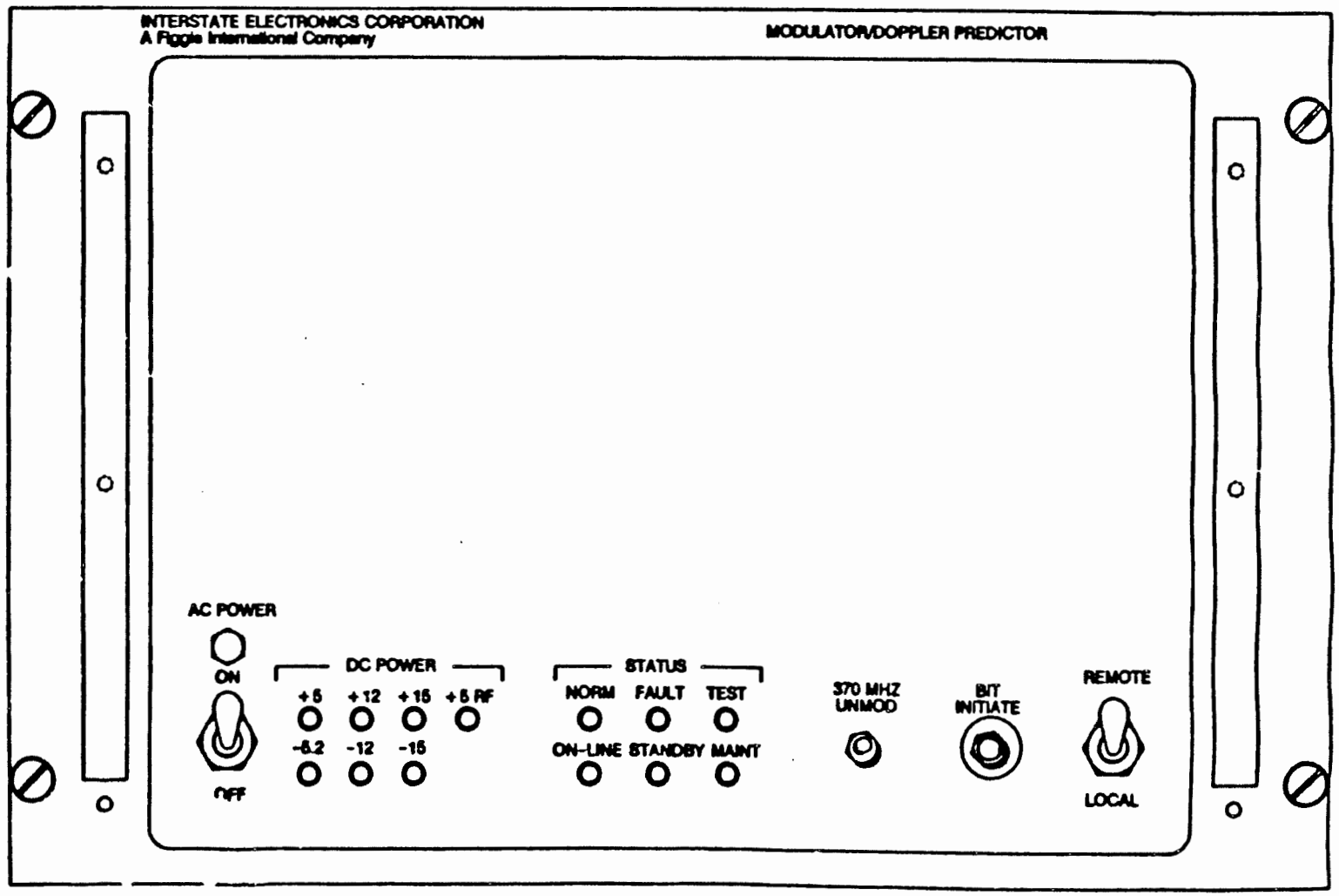


Figure 5. MDP Front Panel

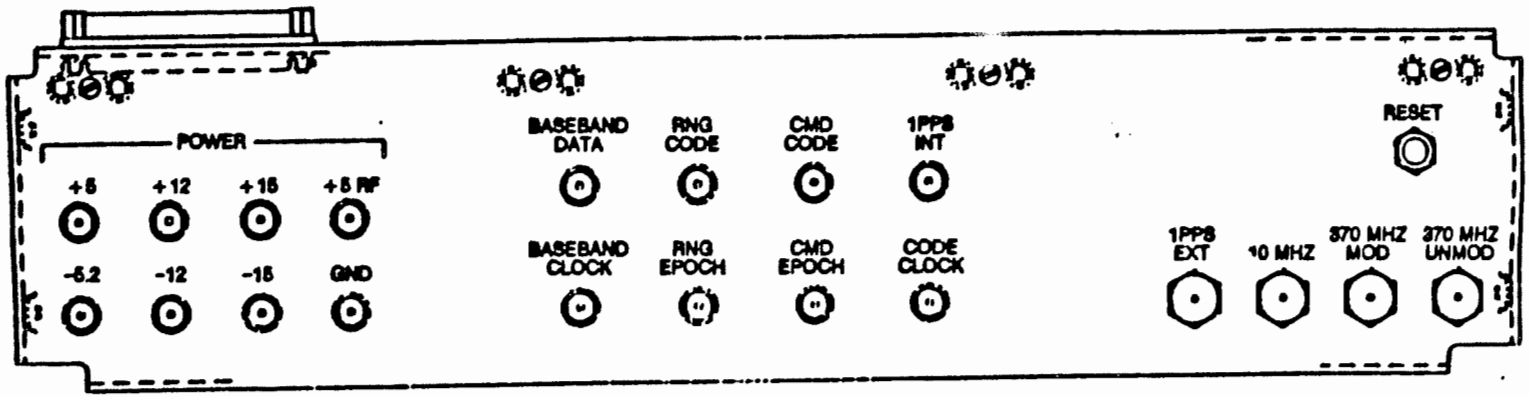
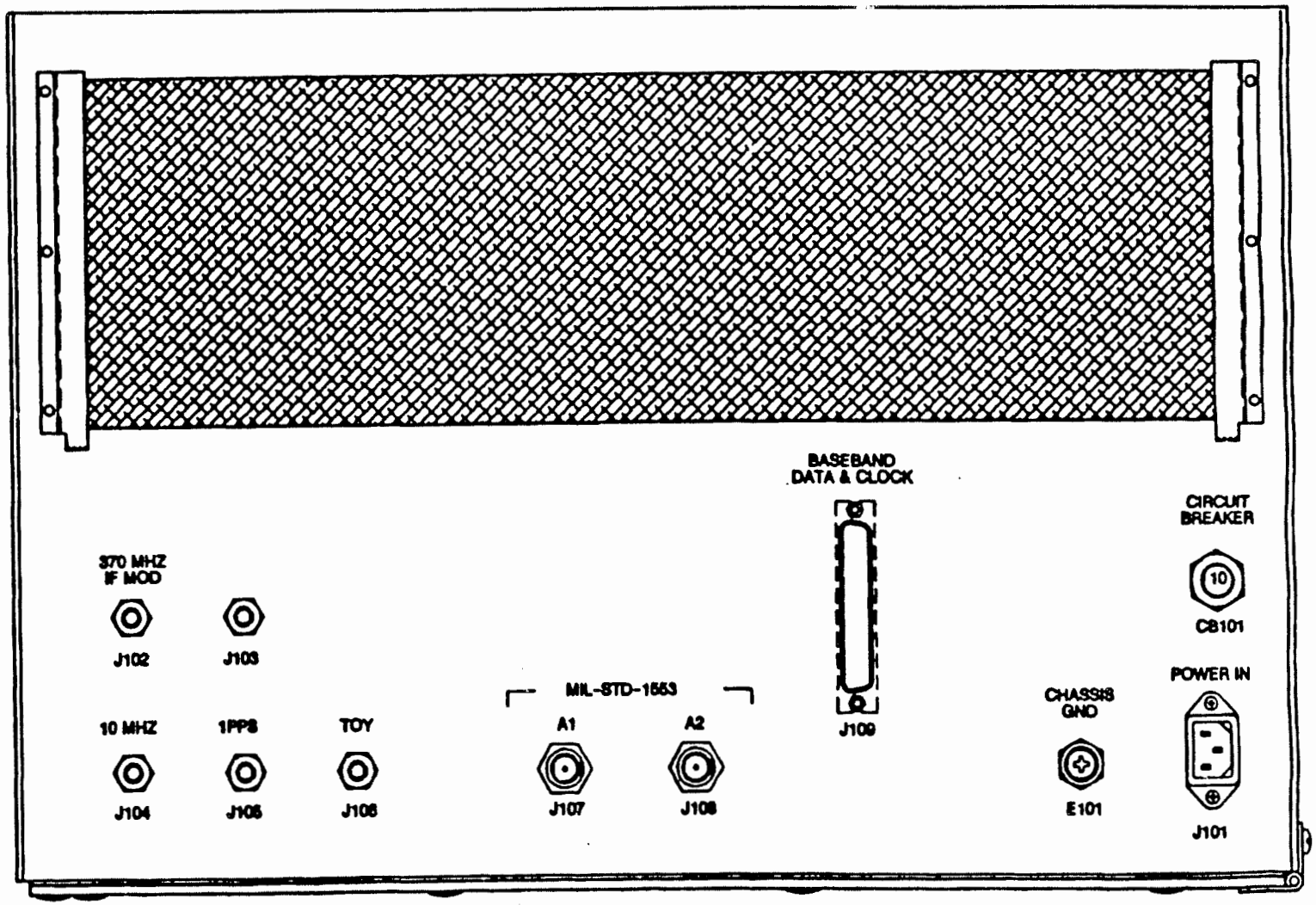


Figure 6. MDP Maintenance Panel



NOTE: The unit back panel is the Primary Interface between the MDP and other configuration items.

Figure 7. MDP Back Panel

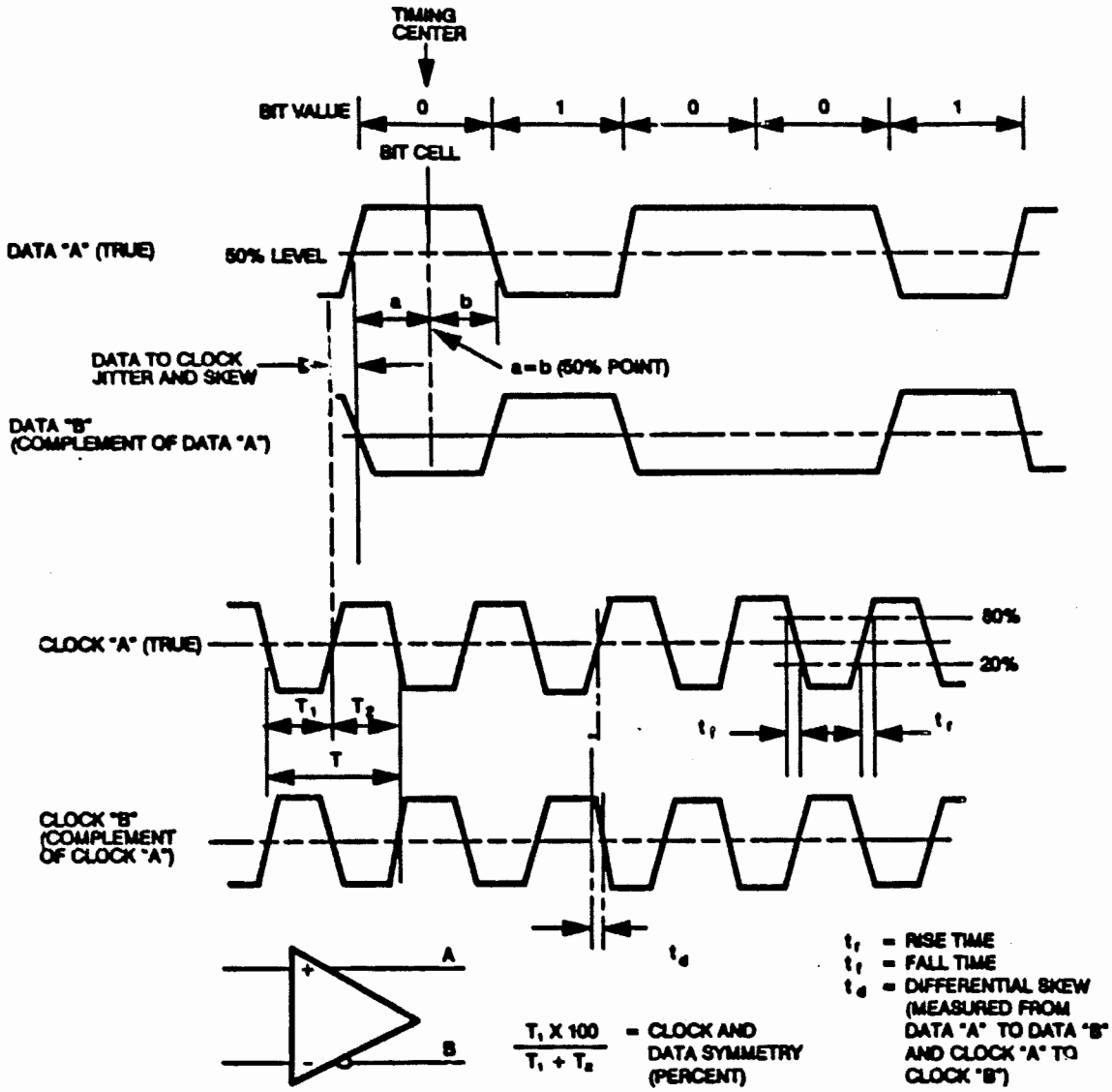


Figure 8. Clock and Data Relationships

INTERSTATE ELECTRONICS CORPORATION	SHEET NUMBER	DOCUMENT NUMBER	REV
	F-8	7472306	C

TABLE I. BACK PANEL CONNECTORS AND SIGNALS

Signal Name	Unit Connector Terminal Number and Type		
Primary AC Power 115 VAC Return (white) Safety Ground (green) 115 VAC Line (black)	J101 J101-A J101-B J101-C	Input	AC Connector
Modulated 370 MHz IF	J102	Output	SMA
Spare	J103	Spare	SMA
CTFS 10 MHz	J104	Input	SMA
CTFS 1 PPS	J105	Input	SMA
CTFS TOY	J106	Input	SMA
MIL-STD-1553B Bus 1 Bus 1 HI (blue) Bus 1 LO (white) Shield (shield)	J107 Center Inner Shield	Input/ Output	Twinax (Threaded)
MIL-STD-1553B Bus 2 Bus 2 HI (blue) Bus 2 LO (white) Shield	J108 Center Inner Shield	Input/ Output	Twinax (Threaded)
USS Forward Data and Clock Command Clock CMDCLK+ CMDCLK- SHIELD Command Data CMDDATA+ CMDDATA- SHIELD Remote Terminal Address RTA0 RTA1 RTA2 RTA3 RTA4 RTAP (parity) RTAR (return)	J109 J109-01 J109-02 J109-03 J109-04 J109-05 J109-06 J109 J109-31 J109-32 J109-33 J109-34 J109-35 J109-36 J109-37	Input	37 pin male D type

TABLE II. MAINTENANCE PANEL CONNECTORS AND SIGNALS

Signal Identification and Connector Termination of Maintenance Panel Signals for the Modulator/Doppler Predictor			
Signal Name	Unit Connector Terminal Number and Type		
+5 Volts DC	TP1	Output	Test Point
+12 Volts DC	TP2	Output	Test Point
+15 Volts DC	TP3	Output	Test Point
+5 Volts DC (RF Supply)	TP7	Output	Test Point
-5.2 Volts DC	TP4	Output	Test Point
-12 Volts DC	TP5	Output	Test Point
-15 Volts DC	TP6	Output	Test Point
Ground	TP8	Ground	Test Point
Forward User Data	TP9	Output	Test Point
Range PN Code	TP11	Output	Test Point
Command PN Code	TP13	Output	Test Point
CTFS 1 PPS Internal	TP15	Output	Test Point
Forward User Clock	TP10	Output	Test Point
Range PN Epoch	TP12	Output	Test Point
Command PN Epoch	TP14	Output	Test Point
PN Code Clock	TP16	Output	Test Point
CTFS 1 PPS External	J5	Output	BNC
CTFS 10 MHz	J1	Output	BNC
370 MHz Modulated	J2	Output	BNC
370 MHz Unmodulated	J3	Output	BNC

TABLE III. FRONT PANEL CONNECTORS AND SIGNALS

Signal Identification and Connector Termination of Front Panel Signals for the Modulator/Doppler Predictor			
Signal Name	Unit Connector Terminal Number and Type		
Unmodulated 370 MHz IF	J1	Output	SMA

NOTES:

1. The Unmodulated 370 MHz IF is not a maintenance test point. It is a mandatory front panel output signal. It may also be used for test.
2. See table XI for characteristics.

TABLE IV. IDENTIFICATION OF CONNECTOR TYPES

Connector Type	IEC Part No.	Vendor Part No.
AC Connector	338-020-090	LE10BC Filter Concepts
SMA Connector	374-215-001	2084-0000-00 Omni
Twinax (Threaded)	374-150-024	BJ379-47 Trompeter
37 Pin Male Type D	373-043-985	17-22370-1 (439) Wire-Pro Inc.
BNC	374-019-017	3284-2240-00 Omni
Test Point	M39024/10-01	M39024/10-01

TABLE V. SIGNAL CHARACTERISTICS AND UNIT INTERFACE REQUIREMENTS FOR PRIMARY AC POWER

Item	Description
Signal Characteristics	
1. Voltage	120 VAC +/- 10%, single phase
2. Frequency	57 Hz to 63 Hz; 60 Hz nominal
3. Power	350 Watts, maximum
Interface Requirements	

1. AC power connector shall have only three pins, designated A, B, and C. Within the unit, color coded conductors shall be connected between pins and the first terminals as follows:

Pin	Conductor Function	Conductor Color*
A	VAC Return	White
B	Safety Ground	Green
C	VAC Line	Black

* AC power cables may be commercial power cords and connectors which meet equivalent standards for safety and function.

TABLE VI. SIGNAL CHARACTERISTICS AND UNIT INTERFACE REQUIREMENTS FOR MIL-STD-1553B DATA BUS

Item	Description
Signal Characteristics	
Signal Characteristics are as per MIL-STD-1553B.	
Unit Interface Requirements	
1. Coupling	Transformer coupled
2. Remote Terminal Address	The unit Remote Terminal Address shall be accommodated via the connector J109 as shown in table I. The MDP shall provide internal pull ups for the input signals.
3. Parity	ODD

TABLE VII. COMMON TIME AND FREQUENCY SYSTEM (CTFS) 10 MHz INPUT

Item		Description
Signal Characteristics		
1.	Nominal frequency	10 MHz
2.	Signal type	Single ended, sinusoidal
3.	Nominal source impedance	50 ohms
4.	Signal level	+ 11 dBm +4/- 3 dB into 50 ohms
5.	Single-sideband (SSB) phase noise in 1 Hz bandwidth	
	Frequency Offset From Carrier (Hz)	Phase Noise (dB_c/Hz)
	0.1	-80
	1	-105
	10	-120
	100	-125
	1,000	-140
6.	Frequency accuracy ($\Delta f/f$)	$+/- 4 \times 10^{-12}$
7.	Frequency stability (square root of zero-dead-time two-sample Allan variance)	
	Averaging Time (Seconds)	Stability
	1	$< +/- 5.0 \times 10^{-12}$
	10	$< +/- 2.7 \times 10^{-12}$
	100	$< +/- 8.5 \times 10^{-13}$
8.	Harmonic distortion	less than -50 dBc
9.	Non-harmonically related spurious	less than -80 dBc
Unit Interface Requirements		
1.	Nominal input impedance	50 ohms
2.	Input VSWR	1.3:1 over (10 +/- 0.5) MHz, maximum

TABLE VIII. COMMON TIME AND FREQUENCY SYSTEM (CTFS) 1 PULSE PER SECOND (1 PPS) INPUT

Item		Description
Signal Characteristics		
1.	Nominal frequency	1 Hz
2.	Signal type	Single ended, rectangular pulse
3.	Nominal source impedance	50 ohms
4.	Signal levels	TTL levels
5.	Pulse width	100 microseconds, +/- 0.1 %
6.	Rise and fall times	10 nanoseconds, maximum
7.	Pulse to pulse jitter	2 nanoseconds, maximum
8.	Accuracy	< +/- 25 nanoseconds, referenced to the CTFS master epoch
9.	Sense of signal	Time epoch corresponds to the leading edge of the pulse
Unit Interface Requirements		
1.	Nominal input impedance	50 ohms
2.	VSWR	1.3:1, (1-35 MHz)

TABLE IX. COMMON TIME AND FREQUENCY SYSTEM (CTFS) TIME OF YEAR (TOY) INPUT

Item		Description
Signal Characteristics		
1.	Nominal frequency	Per IRIG-B Standard, IRIG-STD 104-70
2.	Signal format	IRIG-B level shift
3.	Nominal source impedance	50 ohms
4.	Signal levels	TTL into 50 ohms
5.	Signal type	Single-ended
Unit Interface Requirement		
1.	Nominal input impedance	50 ohms

TABLE X. SIGNAL CHARACTERISTICS AND UNIT INTERFACE REQUIREMENTS FOR MODULATED 370 MHz IF OUTPUT

Item		Description
Signal Characteristics		
1.	Nominal center frequency	370 MHz
2.	Power level	-10 dBm +/- 3 dB
3.	Stability of output power	+/- 1 dB over any 1 hour period (within specified levels)
4.	Spurious signals	
	a. Total RSS of all spurious signals	-35 dBc, maximum
	b. Individual spurious signals (in or out of band)	-40 dBc, maximum
Unit Interface Requirements		
1.	Nominal output impedance	50 ohms
2.	VSWR	1.3:1, maximum, measured over a 50 MHz band centered at 370 MHz

TABLE XI. SIGNAL CHARACTERISTICS AND UNIT INTERFACE REQUIREMENTS FOR UNMODULATED 370 MHz IF OUTPUT

Item		Description
Signal Characteristics		
1.	Nominal center frequency	370 MHz
2.	Power level	- 15 dBm +/- 3 dB
3.	Stability of output power	+/- 1 dB over any 1 hour period (within specified power levels)
4.	Spurious signals	
	a. Total RSS of all spurious signals	-35 dBc
	b. Individual spurious signals (in or out of band)	-40 dBc
Unit Interface Requirements		
1.	Nominal output impedance	50 ohms
2.	VSWR	1.3:1, maximum, measured over a 5 MHz band centered at 370 MHz

TABLE XII. SIGNAL CHARACTERISTICS AND UNIT INTERFACE REQUIREMENTS FOR USS FORWARD DATA AND CLOCK INPUTS

Item	Description
Signal Characteristics	
1. Data format	NRZ
2. Data rate	100 bps - 25 Mbps
3. Clock rate	Same as data and synchronous with the data
4. Signal types	Complementary balanced differential TTL
5. Signal levels	Similar to RS-422A except signal frequency extends to 25 MHz
6. Clock asymmetry	50 +/- 5 percent, maximum
7. Differential (A) to (B) voltage for clock or data	2.0 volts, minimum
8. Time skew (A) to (B) for clock or data	6.5 nanoseconds, maximum
9. Time skew (A) to (A) and (B) to (B) for clock data relative to data	25 percent of a bit period, maximum
10. 20 to 80 percent differential transition time for clock or data	12 nanoseconds, maximum
11. Nominal source impedance	Less than 10 ohms
Unit Interface Requirements	
1. Line driver/receiver	To satisfy these requirements, the chip set used to support 25 Mbps forward data rate is an SN75ALS191 (Texas Instruments) line driver and a DS26C32ACJ (National Semiconductor) line receiver. Equivalent or better chips may be used, provided they satisfy RS-422A type requirements up to 25 Mbps.
2. Input impedance	100 ohms +/- 2% line-to-line for each differential signal pair

Definitions

See figure 8 for an illustration of the parameters defined as follows:

A. SPECIFIED PARAMETERS

1. Clock Asymmetry - This parameter specifies the allowable clock duty cycle around 50 percent.

2. Differential (A) to (B) - This parameter specifies the allowable plus or minus differential voltage to ensure a voltage at the receiver input capable of producing a full receiver output swing.

3. Time Skew (A) to (B) - This parameter identifies the allowed time skew between the (A) cable and the (B) cable of any differentially transmitted signal. The total time varies linearly along the total cable length. The total time skew is the difference between the driver output skew and worst case receiver input skew.

4. Time Skew (A) Data to (A) Clock - This parameter identifies the allowed time skew between a clock signal (on the A cable) and its related data signal or signals (on the A cable). This parameter is evaluated on an instantaneous clock period to data period basis. It includes all combination effects of clock asymmetry and jitter conditions in their total affect on clock transition and data midpoint skew.

B. LOGICAL SENSE

1. The (A) terminal of the driver shall be negative with respect to the (B) terminal for binary 1 exchange.

2. The (A) terminal of the driver shall be positive with respect to the (B) terminal for binary 0 exchange.

3. The significant transition for the clock signal is the negative-going transition of the A signal with respect to the B signal. This transition shall occur within the specified tolerance of the midpoint of the data bit period.

4. All data crossings shall be coincident with positive going clock transitions.

TABLE XIII. DOPPLER PROFILE LIMITS

Service	Frequency Range (+/- kHz)	Frequency Rate (+/- Hz/s)	Frequency Acceleration (+/- Hz/s^2
SSAF, SSHF	85	370	15
KSAF, KSHF	560	700	1
MAF	85	112	0.15

Appendix I

10.0 Not Used.

20.0 TRACEABILITY MATRIX

20.1 SCOPE

This appendix provides a matrix that traces unit level requirements from this specification, 7472306, to requirements given in the General Electric Corporation Hardware Configuration Item (HWCI) Specifications, GES-STGT-1323, -1325, and -1328. The unit is required to satisfy, as a minimum, the requirements of these specifications for a Modulator/Doppler Predictor (MDP).

20.2 TRACEABILITY

20.2.1 Direct Traceability

All Modulator/Doppler Predictor requirements in 7472306 shall be traceable to the referenced GE HWCI specifications, either directly, or through a set of logically derived requirements.

20.2.2 Single Configuration Item

The Modulator/Doppler Predictor constitutes a single configuration item and may be used interchangeably in the K-Band Single Access Low Data Rate Equipment, S-Band Single Access Equipment, or Multiple Access Receiver/Transmit Equipment of the User Services Subsystem (USS) in the Second TDRSS Ground Terminal (STGT). As such, each GE HWCI requirement is satisfied by the unit, but not each unit requirement traces back to all of the HWCI specifications, since not all these configuration items require of the unit's capabilities.

20.3 THE MATRIX

The traceability matrix is presented in the following table.

REQUIREMENTS TRACEABILITY MATRIX

This matrix provides a trace of requirements from the GE HWCI specifications for SSA, KSA, and MA Modulator/Doppler Predictor (MDP) requirements to the IEC performance specification for the MDP. Requirements are traced by service, SSA, KSA, and MA, with the exception of Physcial Characteristics (i.e., boilerplate). A common trace is provided for the boilerplate characteristics.

SSA REQUIREMENTS		
GE, SSA HWCI Paragraph	Title	IEC Unit Paragraph
3.0	REQUIREMENTS	Title
3.1	Hardware Configuration Item Definition	Description
3.1.1	Item Functions	Introduction
3.1.1.1	Integrated Receiver (IR)	N/A
3.1.1.2	Modulator/Doppler Predictor (MDP)	Introduction
	This section refers to paragraph 3.2.1.2.1.3 which traces to IEC specific articles in that paragraph.	
3.1.1.3	PTE Modem	N/A
3.1.2	Major Equipment List	N/A
3.1.3	Interface Definition and Characteristics	Title
3.1.3.1	Integrated Receiver	N/A
3.1.3.2	Modulator/Doppler Predictor (MDP)	3.1.2
3.1.3.2.1	External Interfaces	Title
3.1.3.2.1.1	AC Power	3.1.2.1
3.1.3.2.1.2	1553B Bus	3.1.2.2
3.1.3.2.1.3	Common Time and Frequency Inputs	3.1.2.3 3.1.2.3.1 3.1.2.3.2 3.1.2.3.3
3.1.3.2.1.4	Modulated 370 MHz IF Output	3.1.2.4
3.1.3.2.1.5	Unmodulated 370 MHz IF Output	3.1.2.5
3.1.3.2.1.6	Baseband Data And Clock Inputs	3.1.2.6
3.1.3.3	PTE	N/A
3.1.4	Government furnished Equipment	3.1.4
3.1.5	Customer Furnished Equipment	None
3.2	Characteristics	Title
3.2.1	Performance Characteristics	Introduction
3.2.1.1	Integrated Receiver	N/A
3.2.1.2	Modulator/Doppler Predictor	Title
3.2.1.2.1	MDP Operations and Functions	Title
3.2.1.2.1.1	Commanding	3.1.2.2
3.2.1.2.1.1.1	Configuration Commands	3.1.2.2
3.2.1.2.1.1.1a	MDP Common Configuration Command (Forward Model Configuration)	3.1.2.2,3.1.2.2a
3.2.1.2.1.1.1b	MDP Specific Configuration Command	3.1.2.2,3.1.2.2a
3.2.1.2.1.1.2	Reconfiguration	3.1.2.2.1
3.2.1.2.1.1.2.1	Recovery Reconfiguration	3.1.2.2.1.1
3.2.1.2.1.1.2.1a	Applicable Parameters	3.1.2.2.1.1a
3.2.1.2.1.1.2.1b	Implementation of Recovery Reconfigurations	3.1.2.2.1.1b

GE, SSA HWCI Paragraph	SSA Requirements (Continued) Title	IEC Unit Paragraph
3.2.1.2.1.1.2.1c	Timing	3.1.2.2.1.2c
3.2.1.2.1.1.2.2	Restart Reconfiguration	3.1.2.2.1.2
3.2.1.2.1.1.2.2a	Applicable Parameters	3.1.2.2.1.2a
3.2.1.2.1.1.2.2b	Implementation of Restart Reconfigurations	3.1.2.2.1.2b
3.2.1.2.1.1.2.2c	Timing	3.1.2.2.1.2c
3.2.1.2.1.1.3	Frequency and Delay Profiles This section refers to paragraph 3.2.1.2.2.3 which traces to IEC specific articles in that paragraph.	N/A
3.2.1.2.1.1.4	MDP Control Commands	Description
3.2.1.2.1.2	Operating States	3.2.1.8.1.2.3b
3.2.1.2.1.3	MDP Functions	Introduction
3.2.1.2.1.3a	Accept Commands	3.1k
3.2.1.2.1.3b	Accept Input Data	3.1a
3.2.1.2.1.3c	Data Processing	3.1a
3.2.1.2.1.3d	IF Carrier Generation	3.1d,e
3.2.1.2.1.3e	SSAF and Range Zero Set PN Code Generation	3.1c, 3.1h
3.2.1.2.1.3f	SSHF PN Code Generation	3.1c
3.2.1.2.1.3g	Modulation	3.1d
3.2.1.2.1.3h	Modulated IF Output	3.1d
3.2.1.2.1.3i	Unmodulated IF Output	3.1j
3.2.1.2.1.3j	Status Reporting	3.1i, 3.1k
3.2.1.2.2	MDP Performance Requirements	Title
3.2.1.2.2.1	Modulation	Title
3.2.1.2.2.1.1	Input Data Description	3.2.1.1a,b
3.2.1.2.2.1.2	SSAF Service Link Modulation	Title
3.2.1.2.2.1.2a	Description	3.2.1.4, 3.2.1.4.2 3.2.1.5.1a 3.2.1.5.2
3.2.1.2.2.1.2b	Change in SSAF Data Rates	3.2.1.1a
3.2.1.2.2.1.2c	Data Clock Clamped	3.2.1.3
3.2.1.2.2.1.2d	PN Modulation Inhibit/Enable	3.2.1.4.1a
3.2.1.2.2.1.2e	Start of Modulation	3.2.1.5.3
3.2.1.2.2.1.2f	PN Code Epoch Synchronization	3.2.1.4.4
3.2.1.2.2.1.2g	Effect of PN Modulation On/Off on Epoch Synchronization	3.1.2.2 3.2.1.4.4.1
3.2.1.2.2.1.3	SSHF Service Link Modulation	Title
3.2.1.2.2.1.3a	Description	3.2.1.1b 3.2.1.4 3.2.1.5.1b 3.2.1.5.2
3.2.1.2.2.1.3b	Input Data and Clock Synchronization	3.2.1.1b
3.2.1.2.2.1.3c	Data Clock Clamped	3.2.1.3
3.2.1.2.2.1.3d	PN Modulation Inhibit/Enable	3.2.1.4.1a
3.2.1.2.2.1.3e	Start of Modulation	3.2.1.5.3
3.2.1.2.2.1.3f	PN Code Epoch Synchronization	3.2.1.4.4

GE, SSA HWCI Paragraph	SSA Requirements (Continued) Title	IEC Unit Paragraph
3.2.1.2.2.1.3g	Effect of PN Modulation On/Off on Epoch Synchronization	3.1.2.2 3.2.1.4.4.1
3.2.1.2.2.1.4	Range Zero Set Modulation	Title
3.2.1.2.2.1.4a	Description	3.2.1.7.2
3.2.1.2.2.1.4b	(Not Used)	N/A
3.2.1.2.2.1.4c	Data Clock Clamped	3.2.1.7.2b
3.2.1.2.2.1.4d	(Not Used)	N/A
3.2.1.2.2.1.4e	Start Modulation	3.2.1.4.5
3.2.1.2.2.1.4f	PN Code Epoch Synchronization	3.2.1.4.4
3.2.1.2.2.1.4g	(Not Used)	N/A
3.2.1.2.2.2	(Not Used)	N/A
3.2.1.2.2.3	Doppler Compensation Profile	Title
3.2.1.2.2.3a	Description	3.2.1.6.1 3.2.1.6.1.1 3.2.1.6.1.2a,b 3.2.1.6.1.3 3.2.1.6.1.3.1 3.2.1.6.2c
3.2.1.2.2.3b	Limits	3.2.1.6.1.3.1b
3.2.1.2.2.3c	MDP Capacity	3.2.1.6.1.3.1a
3.2.1.2.2.3d	Profile Updating	3.2.1.6.1.3.1c
3.2.1.2.2.4	MDP Frequency Control for SSAF Services	Title
3.2.1.2.2.4.1	SSAF IF Carrier Frequency Adjustment	3.2.1.6.2
3.2.1.2.2.4.1a	Update Rate	3.2.1.6.2a
3.2.1.2.2.4.1b	Accuracy	3.2.1.6.2b
3.2.1.2.2.4.2	SSAF PN Code Rate	3.2.1.6.3
3.2.1.2.2.4.3	SSAF Frequency Control	Title
3.2.1.2.2.4.3.1	Compensation Inhibited	3.2.1.6.1 3.2.1.6.1.3.1d 3.2.1.6.1.3.2d
3.2.1.2.2.4.3.2	Compensation Enabled	3.2.1.6.1 3.2.1.6.1.3.1d 3.2.1.6.1.3.2d
3.2.1.2.2.4.4	(Not Used)	N/A
3.2.1.2.2.4.5	MDP Frequency Control Command During SSAF Service	3.2.1.6.1.3.5
3.2.1.2.2.4.5.1	Sweep	Title
3.2.1.2.2.4.5.1a	Command Description	3.2.1.6.1.3.2a,b
3.2.1.2.2.4.5.1b	Response to Command	3.2.1.6.1.3.2c,d,e
3.2.1.2.2.4.5.2	Doppler Compensation Control	Title
3.2.1.2.2.4.5.2a	Command Description	3.2.1.6.1.3.4
3.2.1.2.2.4.5.2b	Response to Command	3.2.1.6.1.3.4f
3.2.1.2.2.4.5.3	Forward Break Lock	Title
3.2.1.2.2.4.5.3a	Command Description	3.2.1.6.1.3.3a,b,c,d
3.2.1.2.2.4.5.3b	Response to Command	3.2.1.6.1.3.3e
3.2.1.2.2.5	MDP Frequency Control for SSHF Service	Title
3.2.1.2.2.5.1	SSHF IF Carrier Frequency Adjustment	3.2.1.6.2
3.2.1.2.2.5.1a	Update Rate	3.2.1.6.2a
3.2.1.2.2.5.1b	Accuracy	3.2.1.6.2b
3.2.1.2.2.5.2	SSHF PN Code Rate	N/A

GE, SSA HWCI Paragraph	SSA Requirements (Continued) Title	IEC Unit Paragraph
3.2.1.2.2.5.3	SSHF PN Code and Carrier Frequency at Start of Service Introduction	Title
3.2.1.2.2.5.3.1	Carrier Doppler Compensation Inhibited, PN Doppler Compensation Inhibited	3.2.1.6.1 3.2.1.6.4 3.2.1.6.1.3.1d
3.2.1.2.2.5.3.2	Carrier Doppler Compensation Inhibited, PN Doppler Compensation Enabled	3.2.1.6.1 3.2.1.6.4 3.2.1.6.1.3.1d
3.2.1.2.2.5.3.3	Carrier Doppler Compensation Enable, PN Doppler Compensation Inhibited	3.2.1.6.1 3.2.1.6.4 3.2.1.6.1.3.1d
3.2.1.2.2.5.3.4	Carrier Doppler Compensation Enable, PN Doppler Compensation Enable	3.2.1.6.1 3.2.1.6.4 3.2.1.6.1.3.1d
3.2.1.2.2.5.4	(Not Used)	N/A
3.2.1.2.2.5.5	MDP Frequency Control Command During SSHF Service	3.2.1.6.1.3.5
3.2.1.2.2.5.5.1	Doppler Compensation Control (Carrier Only)	Title
3.2.1.2.2.5.5.1a	Command Description	3.2.1.6.1.3.4
3.2.1.2.2.5.5.1b	Response to Command	3.2.1.6.1.3.4.1
3.2.1.2.2.5.5.2	Doppler Compensation Control (PN Only)	Title
3.2.1.2.2.5.5.2a	Command Description	3.2.1.6.4 3.2.1.6.1.3.4
3.2.1.2.2.5.5.2b	Response to Command	3.2.1.6.4 3.2.1.6.1.3.4.1
3.2.1.2.2.5.5.3	Doppler Compensation Control (Both Carrier and PN)	Title
3.2.1.2.2.5.5.3a	Command Description	3.2.1.6.4 3.2.1.6.1.3.4
3.2.1.2.2.5.5.3b	Response to Command	3.2.1.6.4 3.2.1.6.1.3.4.1
3.2.1.2.2.5.5.4	Forward Break Lock	Title
3.2.1.2.2.5.5.5a	Command Description	3.2.1.6.1.3.3a,b,c,d 3.2.1.6.4
3.2.1.2.2.5.5.5b	Response to Command	3.2.1.6.1.3.3e
3.2.1.2.2.6	MDP Frequency Control for Range Zero Set	Title
3.2.1.2.2.6.1	RZS PN Code Rate	3.2.1.6.3
3.2.1.2.2.6.2	RZS PN Initiation	3.2.1.6.1
3.2.1.2.2.6.3	RZS Doppler Compensation	Title
3.2.1.2.2.6.3a	Doppler Compensation Inhibited	3.2.1.7.2d
3.2.1.2.2.6.3b	Command Execution	3.2.1.7.2d
3.2.1.2.2.7	Carrier and Code Generation	3.2.1.6.1 3.2.1.6.3
3.2.1.2.2.8	Unmodulated IF Carrier Output	3.1.2.5
3.2.1.2.2.9	Carrier I/Q Phase Relationship	3.2.1.5.2a
3.2.1.2.3	Tracking Services	3.2.1.7
3.2.1.2.3.1	Time Transfer Measurement	Title
3.2.1.2.3.1.1	Forward Epoch Time Definition	3.2.1.7.1

GE, SSA HWCI Paragraph	SSA Requirements (Continued) Title	IEC Unit Paragraph
3.2.1.2.3.1.2	Services	3.2.1.7.1a
3.2.1.2.3.1.3	Random Error	3.2.1.7.1c
3.2.1.2.3.1.4	Systematic Error	3.2.1.7.1d
3.2.1.2.3.1.5	Reporting	3.2.1.7.1e
3.2.1.2.4	Performance Measuring and Monitoring Support	Title
	For paragraphs 3.2.2 to 5.1, see Boilerplate Traceability Matrix.	
3.2.1.2.4a	On-Line and Extended BIT	3.2.1.8.1.2 3.2.1.8.1.2.1 3.2.1.8.1.2.2
3.2.1.2.4b	Status Reporting	3.1.2.2 3.2.1.8 & subsequent
3.2.1.2.4c	Front Panel Capabilities	3.1.2, 3.1.2.5, 3.1.2.7, 3.1.2.7.1a & c, 3.1.2.7.3, 3.3.6.3
3.2.1.2.4d	Local/Remote	3.1.2.7.1c

GE, KSA HWCI Paragraph	KSA REQUIREMENTS Title	IEC Unit Paragraph
3.0	REQUIREMENTS	Title
3.1	Hardware Configuration Item Definition	Description
3.1.1	Item Functions	Introduction
3.1.1.1	Integrated Receiver (IR)	N/A
3.1.1.2	Modulator/Doppler Predictor (MDP)	Introduction
	This section refers to paragraph 3.2.1.2.1.3 which traces to IEC specific articles in that paragraph.	
3.1.1.3	PTE Modem	N/A
3.1.2	Major Equipment List	N/A
3.1.3	Interface Definition and Characteristics	Title
3.1.3.1	Integrated Receiver	N/A
3.1.3.2	Modulator/Doppler Predictor (MDP)	3.1.2
3.1.3.2.1	External Interfaces	Title
3.1.3.2.1.1	AC Power	3.1.2.1
3.1.3.2.1.2	1553B Bus	3.1.2.2
3.1.3.2.1.3	Common Time and Frequency Inputs	3.1.2.3 3.1.2.3.1 3.1.2.3.2 3.1.2.3.3
3.1.3.2.1.4	Modulated 370 MHz IF Output	3.1.2.4
3.1.3.2.1.5	Unmodulated 370 MHz IF Output	3.1.2.5
3.1.3.2.1.6	Baseband Data And Clock Inputs	3.1.2.6
3.1.3.3	PTE	N/A
3.1.4	Government furnished Equipment	3.1.4
3.1.5	Customer Furnished Equipment	None
3.2	Characteristics	Title
3.2.1	Performance Characteristics	Introduction
3.2.1.1	Integrated Receiver	N/A
3.2.1.2	Modulator/Doppler Predictor	Title
3.2.1.2.1	MDP Operations and Functions	Title
3.2.1.2.1.1	Commanding	3.1.2.2
3.2.1.2.1.1.1	Configuration Commands	3.1.2.2
3.2.1.2.1.1.1a	MDP Common Configuration Command (Forward Model Configuration)	3.1.2.2, 3.1.2.2a
3.2.1.2.1.1.1b	MDP Specific Configuration Command	3.1.2.2, 3.1.2.2a
3.2.1.2.1.1.2	Reconfiguration	3.1.2.2.1
3.2.1.2.1.1.2.1	Recovery Reconfiguration	3.1.2.2.1.1
3.2.1.2.1.1.2.1a	Applicable Parameters	3.1.2.2.1.1a
3.2.1.2.1.1.2.1b	Implementation of Recovery Reconfigurations	3.1.2.2.1.1b
3.2.1.2.1.1.2.1c	Timing	3.1.2.2.1.1c
3.2.1.2.1.1.2.2	Restart Reconfiguration	3.1.2.2.1.2
3.2.1.2.1.1.2.2a	Applicable Parameters	3.1.2.2.1.2a
3.2.1.2.1.1.2.2b	Implementation of Restart Reconfigurations	3.1.2.2.1.2b
3.2.1.2.1.1.2.2c	Timing	3.1.2.2.1.2c
3.2.1.2.1.1.3	Frequency and Delay Profiles	N/A

GE, KSA HWCI Paragraph	KSA Requirements (Continued) Title	IEC Unit Paragraph
	This section refers to paragraph 3.2.1.2.2.3 which traces to IEC specific articles in that paragraph.	
3.2.1.2.1.1.4	MDP Control Commands	Description
3.2.1.2.1.2	Operating States	3.2.1.8.1.2.3b
3.2.1.2.1.3	MDP Functions	Introduction
3.2.1.2.1.3a	Accept Commands	3.1k
3.2.1.2.1.3b	Accept Input Data	3.1a
3.2.1.2.1.3c	Data Processing	3.1a
3.2.1.2.1.3d	IF Carrier Generation	3.1d,e
3.2.1.2.1.3e	KSAF,KSHF, and Range Zero Set PN Code Generation	3.1c, 3.1h
3.2.1.2.1.3f	Not Used	N/A
3.2.1.2.1.3g	Modulation	3.1d
3.2.1.2.1.3h	Modulated IF Output	3.1d
3.2.1.2.1.3i	Unmodulated IF Output	3.1j
3.2.1.2.1.3j	Status Reporting	3.1i, 3.1k
3.2.1.2.2	MDP Performance Requirements	Title
3.2.1.2.2.1	Modulation	Title
3.2.1.2.2.1.1	Input Data Description	3.2.1.1c,d
3.2.1.2.2.1.2	KSAF Service Link Modulation	Title
3.2.1.2.2.1.2a	Description	3.2.1.4, 3.2.1.4.2 3.2.1.5.1c 3.2.1.5.2
3.2.1.2.2.1.2b	Change in KSAF Data Rates	3.2.1.1c
3.2.1.2.2.1.2c	Data Clock Clamped	3.2.1.3
3.2.1.2.2.1.2d	PN Modulation Inhibit/Enable	3.2.1.4.1a
3.2.1.2.2.1.2e	Start of Modulation	3.2.1.5.3
3.2.1.2.2.1.2f	PN Code Epoch Synchronization	3.2.1.4.4
3.2.1.2.2.1.2g	Effect of PN Modulation On/Off on Epoch Synchronization	3.1.2.2 3.2.1.4.4.1
3.2.1.2.2.1.3	KSHF Service Link Modulation	Title
3.2.1.2.2.1.3a	Description	3.2.1.1d 3.2.1.4 3.2.1.5.1d 3.2.1.5.2
3.2.1.2.2.1.3b	Input Data and Clock Synchronization	N/A
3.2.1.2.2.1.3c	Data Clock Clamped	3.2.1.3
3.2.1.2.2.1.3d	PN Modulation Inhibit/Enable	3.2.1.4.1a
3.2.1.2.2.1.3e	Start of Modulation	3.2.1.5.3
3.2.1.2.2.1.3f	PN Code Epoch Synchronization	3.2.1.4.4
3.2.1.2.2.1.3g	Effect of PN Modulation On/Off on Epoch Synchronization	3.1.2.2 3.2.1.4.4.1
3.2.1.2.2.1.4	Range Zero Set Modulation	Title
3.2.1.2.2.1.4a	Description	3.2.1.7.2
3.2.1.2.2.1.4b	(Not Used)	N/A
3.2.1.2.2.1.4c	Data Clock Clamped	3.2.1.7.2b
3.2.1.2.2.1.4d	(Not Used)	N/A
3.2.1.2.2.1.4e	Start Modulation	3.2.1.4.5

GE, KSA HWCI Paragraph	KSA Requirements (Continued) Title	IEC Unit Paragraph
3.2.1.2.2.1.4f	PN Code Epoch Synchronization	3.2.1.4.4
3.2.1.2.2.1.4g	(Not Used)	N/A
3.2.1.2.2.2	(Not Used)	N/A
3.2.1.2.2.3	Doppler Compensation Profile	Title
3.2.1.2.2.3a	Description	3.2.1.6.1
		3.2.1.6.1.1
		3.2.1.6.1.2a,b
		3.2.1.6.1.3
		3.2.1.6.1.3.1
		3.2.1.6.2c
3.2.1.2.2.3b	Limits	3.2.1.6.1.3.1b
3.2.1.2.2.3c	MDP Capacity	3.2.1.6.1.3.1a
3.2.1.2.2.3d	Profile Updating	3.2.1.6.1.3.1c
3.2.1.2.2.4	MDP Frequency Control for KSAF and KSHF Services	Title
3.2.1.2.2.4.1	KSAF and KSHF IF Carrier Frequency Adjustment	3.2.1.6.2
3.2.1.2.2.4.1a	Update Rate	3.2.1.6.2a
3.2.1.2.2.4.1b	Accuracy	3.2.1.6.2b
3.2.1.2.2.4.2	KSAF and KSHF PN Code Rate	3.2.1.6.3
3.2.1.2.2.4.3	KSAF and KSHF Frequency Control	Title
3.2.1.2.2.4.3.1	Compensation Inhibited	3.2.1.6.1
		3.2.1.6.1.3.1d
		3.2.1.6.1.3.2d
3.2.1.2.2.4.3.2	Compensation Enabled	3.2.1.6.1
		3.2.1.6.1.3.1d
		3.2.1.6.1.3.2d
3.2.1.2.2.4.4	(Not Used)	N/A
3.2.1.2.2.4.5	MDP Frequency Control Command During KSAF or KSHF Service	3.2.1.6.1.3.5
3.2.1.2.2.4.5.1	Sweep	Title
3.2.1.2.2.4.5.1a	Command Description	3.2.1.6.1.3.2a,b
3.2.1.2.2.4.5.1b	Response to Command	3.2.1.6.1.3.2c,d,e
3.2.1.2.2.4.5.2	Doppler Compensation Control	Title
3.2.1.2.2.4.5.2a	Command Description	3.2.1.6.1.3.4
3.2.1.2.2.4.5.2b	Response to Command	3.2.1.6.1.3.4.1
3.2.1.2.2.4.5.3	Forward Break Lock	Title
3.2.1.2.2.4.5.3a	Command Description	3.2.1.6.1.3.3a,b,c,d
3.2.1.2.2.4.5.3b	Response to Command	3.2.1.6.1.3.3
3.2.1.2.2.5	(Not Used)	N/A
3.2.1.2.2.6	MDP Frequency Control for Range Zero Set	Title
3.2.1.2.2.6.1	RZS PN Code Rate	3.2.1.6.3
3.2.1.2.2.6.2	RZS PN Initiation	3.2.1.6.1
3.2.1.2.2.6.3	RZS Doppler Compensation	Title
3.2.1.2.2.6.3a	Doppler Compensation Inhibited	3.2.1.7.2d
3.2.1.2.2.6.3b	Command Execution	3.2.1.7.2d
3.2.1.2.2.7	Carrier and Code Generation	3.2.1.6.1
		3.2.1.6.3
3.2.1.2.2.8	Unmodulated IF Carrier Output	3.1.2.5
3.2.1.2.2.9	Carrier I/Q Phase Relationship	3.2.1.5.2a
3.2.1.2.3	Tracking Services	3.2.1.7

GE, KSA HWCI Paragraph	KSA Requirements (Continued) Title	IEC Unit Paragraph
3.2.1.2.3.1	Time Transfer Measurement	Title
3.2.1.2.3.1.1	Forward Epoch Time Definition	3.2.1.7.1
3.2.1.2.3.1.2	Services	3.2.1.7.1a
3.2.1.2.3.1.3	Random Error	3.2.1.7.1c
3.2.1.2.3.1.4	Systematic Error	3.2.1.7.1d
3.2.1.2.3.1.5	Reporting	3.2.1.7.1e
3.2.1.2.4	Performance Measuring and Monitoring Support	Title
	For paragraphs 3.2.2 to 5.1 see Boilerplate Traceability Matrix.	
3.2.1.2.4a	On-Line and Extended BIT	3.2.1.8.1.2 3.2.1.8.1.2.1 3.2.1.8.1.2.2
3.2.1.2.4b	Status Reporting	3.1.2.2 3.2.1.8 & subsequent
3.2.1.2.4c	Front Panel Capabilities	3.1.2, 3.1.2.5, 3.1.2.7, 3.1.2.7.1a,c, 3.1.2.7.3, 3.3.6.3, 3.3.6.3
3.2.1.2.4d	Local/Remote	3.1.2.7.1c

GE, MA HWCI Paragraph	MA REQUIREMENTS Title	IEC Unit Paragraph
3.0	REQUIREMENTS	Title
3.1	Hardware Configuration Item Definition	Description
3.1.1	Item Functions	Introduction
3.1.1.1	Integrated Receiver (IR)	N/A
3.1.1.2	Modulator/Doppler Predictor (MDP)	Introduction
	This section refers to paragraph 3.2.1.2.1.3 which traces to IEC specific articles in that paragraph.	
3.1.1.3	PTE Modem	N/A
3.1.2	Major Equipment List	N/A
3.1.3	Interface Definition and Characteristics	Introduction
3.1.3.1	Integrated Receiver	N/A
3.1.3.2	Modulator/Doppler Predictor (MDP)	3.1.2
3.1.3.2.1	External Interfaces	Title
3.1.3.2.1.1	AC Power	3.1.2.1
3.1.3.2.1.2	1553B Bus	3.1.2.2
3.1.3.2.1.3	Common Time and Frequency Inputs	3.1.2.3 3.1.2.3.1 3.1.2.3.2 3.1.2.3.3
3.1.3.2.1.4	Modulated 370 MHz IF Output	3.1.2.4
3.1.3.2.1.5	Not Used	N/A
3.1.3.2.1.6	Baseband Data And Clock Inputs	3.1.2.6
3.1.3.3	PTE	N/A
3.1.4	Government furnished Equipment	3.1.4
3.1.5	Customer Furnished Equipment	None
3.2	Characteristics	Title
3.2.1	Performance Characteristics	Introduction
3.2.1.1	Integrated Receiver	N/A
3.2.1.2	Modulator/Doppler Predictor	Title
3.2.1.2.1	MDP Operations and Functions	Title
3.2.1.2.1.1	Commanding	3.1.2.2
3.2.1.2.1.1.1	Configuration Commands	3.1.2.2
3.2.1.2.1.1.1a	MDP Common Configuration Command (Forward Model Configuration)	3.1.2.2,3.1.2.2a
3.2.1.2.1.1.1b	MDP Specific Configuration Command	3.1.2.2,3.1.2.2a
3.2.1.2.1.1.2	Reconfiguration	3.1.2.2.1
3.2.1.2.1.1.2.1	Recovery Reconfiguration	3.1.2.2.1.1
3.2.1.2.1.1.2.1a	Applicable Parameters	3.1.2.2.1.1a
3.2.1.2.1.1.2.1b	Implementation of Recovery Reconfigurations	3.1.2.2.1.1b
3.2.1.2.1.1.2.1c	Timing	3.1.2.2.1.1c
3.2.1.2.1.1.2.2	Restart Reconfiguration	3.1.2.2.1.2
3.2.1.2.1.1.2.2a	Applicable Parameters	3.1.2.2.1.2a
3.2.1.2.1.1.2.2b	Implementation of Restart Reconfigurations	3.1.2.2.1.2b
3.2.1.2.1.1.2.2c	Timing	3.1.2.2.1.2c
3.2.1.2.1.1.3	Frequency and Delay Profiles	N/A

GE, MA HWCI Paragraph	MA Requirements (Continued) Title	IEC Unit Paragraph
	This section refers to paragraph 3.2.1.2.2.3 which traces to IEC specific articles in that paragraph.	
3.2.1.2.1.1.4	MDP Control Commands	Description
3.2.1.2.1.2	Operating States	3.1.2.2
		3.2.1.8.1.2.3b
3.2.1.2.1.3	MDP Functions	3.1
3.2.1.2.1.3a	Accept Commands	3.1k
3.2.1.2.1.3b	Accept Input Data	3.1a
3.2.1.2.1.3c	Data Processing	N/A
3.2.1.2.1.3d	IF Carrier Generation	3.1d,e
3.2.1.2.1.3e	MAF, and Range Zero Set PN Code Generation	3.1c, 3.1h
3.2.1.2.1.3f	Not Used	N/A
3.2.1.2.1.3g	Modulation	3.1d
3.2.1.2.1.3h	Modulated IF Output	3.1d
3.2.1.2.1.3i	Unmodulated IF Output	N/A
3.2.1.2.1.3j	Status Reporting	3.1i, 3.1k
3.2.1.2.2	MDP Performance Requirements	Title
3.2.1.2.2.1	Modulation	Title
3.2.1.2.2.1.1	Input Data Description	3.2.1.1e
3.2.1.2.2.1.2	MAF Service Link Modulation	Introduction
3.2.1.2.2.1.2a	Description	3.2.1.4, 3.2.1.4.2
		3.2.1.5.1e
		3.2.1.5.2
3.2.1.2.2.1.2b	Change in MAF Data Rates	3.2.1.1e
3.2.1.2.2.1.2c	Data Clock Clamped	3.2.1.3
3.2.1.2.2.1.2d	PN Modulation Inhibit/Enable	3.2.1.4.1a
3.2.1.2.2.1.2e	Start of Modulation	3.2.1.5.3
3.2.1.2.2.1.2f	PN Code Epoch Synchronization	3.2.1.4.4
3.2.1.2.2.1.2g	Effect of PN Modulation On/Off on Epoch Synchronization	3.1.2.2
		3.2.1.4.4.1
3.2.1.2.2.1.3	Range Zero Set Modulation	Title
3.2.1.2.2.1.3a	Description	3.2.1.7.2
3.2.1.2.2.1.3b	(Not Used)	N/A
3.2.1.2.2.1.3c	Data Clock Clamped	3.2.1.7.2b
3.2.1.2.2.1.3d	(Not Used)	N/A
3.2.1.2.2.1.3e	Start Modulation	3.2.1.5.3
3.2.1.2.2.1.3f	PN Code Epoch Synchronization	3.2.1.4.4
3.2.1.2.2.1.3g	(Not Used)	N/A
3.2.1.2.2.2	(Not Used)	N/A
3.2.1.2.2.3	Doppler Compensation Profile	Title
3.2.1.2.2.3a	Description	3.2.1.6.1
		3.2.1.6.1.1
		3.2.1.6.1.2a
		3.2.1.6.1.3
		3.2.1.6.1.3.1
		3.2.1.6.2c
3.2.1.2.2.3b	Limits	3.2.1.6.1.3.1b

GE, MA HWCI Paragraph	MA Requirements (Continued) Title	IEC Unit Paragraph
3.2.1.2.2.3c	MDP Capacity	3.2.1.6.1.3.1a
3.2.1.2.2.3d	Profile Updating	3.2.1.6.1.3.1c
3.2.1.2.2.4	MDP Frequency Control for MAF Services	Title
3.2.1.2.2.4.1	MAF IF Carrier Frequency Adjustment	3.2.1.6.2
3.2.1.2.2.4.1a	Update Rate	3.2.1.6.2a
3.2.1.2.2.4.1b	Accuracy	3.2.1.6.2b
3.2.1.2.2.4.2	MA PN Code Rate	3.2.1.6.3
3.2.1.2.2.4.3	MAF Frequency Control	Title
3.2.1.2.2.4.3.1	Compensation Inhibited	3.2.1.6.1 3.2.1.6.1.3.1d 3.2.1.6.1.3.2d
3.2.1.2.2.4.3.2	Compensation Enabled	3.2.1.6.1 3.2.1.6.1.3.1d 3.2.1.6.1.3.2d
3.2.1.2.2.4.4	(Not Used)	N/A
3.2.1.2.2.4.5	MDP Frequency Control Command During MAF Service	3.2.1.6.1.3.5
3.2.1.2.2.4.5.1	Sweep	Title
3.2.1.2.2.4.5.1a	Command Description	3.2.1.6.1.3.2a,b
3.2.1.2.2.4.5.1b	Response to Command	3.2.1.6.1.3.2c,d,e
3.2.1.2.2.4.5.2	Doppler Compensation Control	Title
3.2.1.2.2.4.5.2a	Command Description	3.2.1.6.1.3.4
3.2.1.2.2.4.5.2b	Response to Command	3.2.1.6.1.3.4.1
3.2.1.2.2.4.5.3	Forward Break Lock	Title
3.2.1.2.2.4.5.3a	Command Description	3.2.1.6.1.3.3a,b,c,d
3.2.1.2.2.4.5.3b	Response to Command	3.2.1.6.1.3.3e
3.2.1.2.2.5	(Not Used)	N/A
3.2.1.2.2.6	MDP Frequency Control for Range Zero Set	Title
3.2.1.2.2.6.1	RZS PN Code Rate	3.2.1.6.3
3.2.1.2.2.6.2	RZS PN Initiation	3.2.1.6.1
3.2.1.2.2.6.3	RZS Doppler Compensation	Title
3.2.1.2.2.6.3a	Doppler Compensation Inhibited	3.2.1.7.2d
3.2.1.2.2.6.3b	Command Execution	3.2.1.7.2d
3.2.1.2.2.7	Carrier and Code Generation	3.2.1.6.1 3.2.1.6.3
3.2.1.2.2.8	Not Used	N/A
3.2.1.2.2.9	Carrier I/Q Phase Relationship	3.2.1.5.2a
3.2.1.2.3	Tracking Services	3.2.1.7
3.2.1.2.3.1	Time Transfer Measurement	Title
3.2.1.2.3.1.1	Forward Epoch Time Definition	3.2.1.7.1
3.2.1.2.3.1.2	Services	3.2.1.7.1a
3.2.1.2.3.1.3	Random Error	3.2.1.7.1c
3.2.1.2.3.1.4	Systematic Error	3.2.1.7.1d
3.2.1.2.3.1.5	Reporting	3.2.1.7.1e
3.2.1.2.4	Performance Measuring and Monitoring Support	Title
	For paragraphs 3.2.2 to 5.1 see Boilerplate Traceability Matrix.	

GE HWCI Paragraph	BOILERPLATE REQUIREMENTS Title	IEC Unit Paragraph
3.2.1.2.4a	On-Line and Extended BIT	3.2.1.8.1.2 3.2.1.8.1.2.1 3.2.1.8.1.2.2
3.2.1.2.4b	Status Reporting	3.1.2.2, 3.2.1.8 & subsequent
3.2.1.2.4c	Front Panel Capabilities	3.1.2, 3.1.2.5, 3.1.2.7, 3.1.2.7.1a & c, 3.1.2.7.3, 3.3.6.3
3.2.1.2.4d	Local/Remote	3.1.2.7.1c
3.2.2	Physical Characteristics	3.2.2
3.2.2.1	Size	3.2.2.1
3.2.2.2	Weight	3.2.2.2
3.2.2.3	Packaging	3.2.2
3.2.2.3.1	Rack Packaging	N/A
3.2.2.3.2	Chassis Packaging	3.2.2, 3.2.2.1, 3.3.1.5, 3.3.3
3.2.2.4	Cabling	3.2.2
3.2.2.5	Cooling	N/A
3.2.2.6	Acoustical Noise	3.2.3.3
3.2.3	Reliability	3.2.3
3.2.3.1	Mean Time Between Failures (MTBF)	3.2.3, 3.2.3.1
3.2.3.2	Design Life	3.2.3.2
3.2.3.3	Operational Capability	N/A
3.2.4	Maintainability	3.2.4
3.2.4.1	Line Replaceable Unit (LRU) Replacement	3.2.4.1
3.2.4.1.1	LRU Definition	3.2.4.1.1
3.2.4.2	Mean Time to Repair (MTTR)	3.2.4.2
3.2.4.3	Maximum Time to Repair (MTR)	3.2.4.3
3.2.4.4	Self Test	3.2.1.8.1
3.2.4.4.1	Confidence Test	3.2.1.8.2.1
3.2.4.4.2	Operational Test	3.2.1.8
3.2.4.4.3	Isolation of a Malfunction	3.5.1.3, 3.5.1.2 & 3.5.1.3.1
3.2.4.4.4	Fault Isolation Performance Requirements	N/A
3.2.4.4.5	Test Via Standard Commercial Test Equipment	3.5.1.3
3.2.4.4.6	Fault Isolation Using Extended BIT	3.2.1.8.1.2.2
3.2.4.5	Maintainability Demonstration	N/A
3.2.5	Environmental Conditions	Title
3.2.5.1	Non-Operating-Shipping and Storage	3.2.5.1
3.2.5.1.1	Temperature	3.2.5.1.a
3.2.5.1.2	Humidity	3.2.5.1.b
3.2.5.1.3	Altitude	3.2.5.1.c
3.2.5.1.4	Solar Radiation	3.5.5.1.d
3.2.5.2	Operating - Environmentally Controlled Area	3.2.5.2
3.2.5.2.1	Temperature	3.2.5.2.a
3.2.5.2.2	Humidity	3.2.5.2.b
3.2.5.2.3	Altitude	3.2.5.2.c
3.2.6	Transportability	3.2.6
3.3	Design and Construction	3.3

GE HWCI Paragraph	Boilerplate Requirements (Continued) Title	IEC Unit Paragraph
3.3.1	Parts, Material and Processes	3.3.1
3.3.1.1	Standard and Non-Standard Parts and Materials	3.3.1.2
3.3.1.1.1	Standard Parts and Material	3.3.1.2.1
3.3.1.1.2	Non-Standard Parts and Materials	3.3.1.2.2
3.3.1.1.3	Programming and Handling of Semiconductor Devices	3.3.1.2.4
3.3.1.2	Standard Components	3.3.1.2.3
3.3.2	Electrical Design	Title
3.3.2.1	Electrical Connections	Title
3.3.2.1.1	Attachment of Wires and Leads	3.3.1.7.1.1
3.3.2.1.2	Solderless Wrap	3.3.1.7.1.2
3.3.2.1.3	Soldered Connections	3.3.1.7.1.3
3.3.2.2	Electrical/Electronic Parts	3.3.1.7.2
3.3.2.3	Electrical Power	3.3.1.7.3
3.3.2.3.1	Single-Phase Power	3.1.2.1, 3.3.1.7.3.1 & 3.3.6.1
3.3.2.3.2	Power Cable Connections	N/A
3.3.2.3.3	Power Transient Susceptibility	3.3.1.7.3.2
3.3.2.3.4	Rack Mounted Chassis Power	N/A
3.3.2.3.5	Overload Protection	3.3.1.7.3.3
3.3.2.3.5.1	Primary Circuit Fuses	3.3.1.7.3.4
3.3.2.3.5.2	Circuit Breakers	3.3.1.7.3.5
3.3.2.3.6	Power Loss Reporting	N/A
3.3.2.3.7	Batteries	N/A
3.3.2.4	Printed Wiring	3.3.1.7.4
3.3.2.4.1	Single or Double Sided Printed Wiring Boards	3.3.1.7.5
3.3.2.4.2	Multilayer Printed Wiring Boards	3.3.1.7.6
3.3.2.5	Preferred Circuits	3.3.1.7.7
3.3.2.6	ARC Suppression	N/A
3.3.3	Mechanical Design	Title
3.3.3.1	Accessibility	3.3.1.8.1
3.3.3.2	Structural Integrity	3.3.1.8.2
3.3.3.3	Captive Hardware	3.3.1.8.3
3.3.3.4	Coating, Treatment and Painting	3.3.1.4 & 3.3.1.3
3.3.3.5	Thermal Design	3.3.1.9
3.3.3.6	Structural Welding	N/A
3.3.4	Electromagnetic Compatibility (EMC) Control	3.3.1.3, 3.3.2
3.3.4.1	EMI Development Testing	3.3.2.1
3.3.4.2	Commercial-Off-The-Shelf (COTS) Equipment	N/A
3.3.5	Grounding, Bonding and Shielding	3.3.1.5
3.3.6	Red/Black Isolation	N/A
3.3.7	Identification and Marking	3.3.3, 3.3.1.6, 3.3.6
3.3.8	Workmanship	3.3.4
3.3.9	Interchangeability/Producibility	Title
3.3.9.1	Interchangeability	3.3.5.1
3.3.9.2	Producibility	3.3.5.2
3.3.10	Safety Criteria	3.3.6
3.3.10.1	Leakage Current	3.3.6.1
3.3.10.2	Power Supply Protection	3.3.6.2
3.3.10.3	Printed Circuit Assembly Protection	3.3.6.3.1
3.3.10.4	Equipment Electrical Power-ON-OFF Switch	3.3.6.3

GE HWCI Paragraph	Boilerplate Requirements (Continued) Title	IEC Unit Paragraph
3.3.10.5	Power Indicator Lamp	3.3.6.4
3.3.10.6	Electrical Cable Protection	3.3.6.5
3.3.10.7	Support Strength	3.3.6.6
3.3.10.8	Equipment Access Security	3.3.6.7
3.3.10.9	Critical Controls	3.3.6.8
3.3.10.10	Human Error Design Protection	3.3.6.9
3.3.10.11a, b, c, d	Unacceptable Materials	3.3.6.10
3.3.10.12	Test Circuit Protection	3.3.6.11
3.3.11	Human Engineering	3.3.7
3.3.11.e	Physical Keying	3.3.5.1.d
3.3.12	Standards of Manufacture	N/A
3.4	Documentation	N/A
3.5	Logistics	3.5
3.5.1	Maintenance Levels	N/A
3.5.1.1	On-Line Corrective Maintenance, First Level Maintenance	3.5.1.3
3.5.1.1.1	Use of Maintenance Test Group	N/A
3.5.1.1.2	In-Circuit Preventive Maintenance, First Level Maintenance	3.5.1.3.2
3.5.1.2	Off-Line Maintenance, Second Level Maintenance	N/A
3.5.1.2.1	Hardware Maintenance Depot (HMD)	N/A
3.5.1.2.2	Vendor Maintenance	N/A
3.5.1.2.2.1	On-Line Equipment Resupply	N/A
3.5.1.2.2.2	Configuration Management	N/A
4.0	Quality Assurance Provisions	Title
4.1	General	4.1
4.1.1	Responsibility for Verifications	4.1.1
4.1.1.1	Quality Assurance Requirements	4.1.1.1
4.2	Quality Conformance Verifications	4.2
4.2.1	Test	4.2.1
4.2.2	Inspections	4.2.2
4.2.3	Demonstration	4.2.3
4.2.4	Analysis	4.2.4
4.2.5	Method Annotation	4.2.5
5.0	Preparation For Delivery	Title
5.1	Preservation, Packaging, and Marking	5.0

APPENDIX III

30.0 TEST MATRIX

30.1 SCOPE
Reference IEC Document C901E3860.